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SOCIETY WINTER MEETING
VICTORY DINNER
NEW YORK
FEBRUARY 4-6

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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1919 ANNUAL SOCIETY MEETING
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THE most significant mechanical development of the twentieth century is the internal-combustion engine. The great industry engaged in the manufacture of automobiles, motor trucks and tractors extends its roots throughout much of the industrial fabric of the country. Transportation, food production, and a large branch of manufacturing are all concerned. These very pertinent and forceful observations are made by Gilbert and Pogue in their masterly "Resource Interpretation of Petroleum," issued recently in pamphlet form by the American National Museum.

The associated manufacturers have asserted that the factories and stores of the United States are at present almost depleted of their normal stocks and that our country is on the threshold of a most unprecedented business expansion. A publicist of national reputation has pointed out that with the pressing needs of the world at this time for commodities of all kinds, unemployment can only occur as the result of general industrial disorganization and confusion. With proper leadership and management, aided by general good will, more than ever before can be accomplished. The real problem of society is how to bring about a general comprehension of the interests which all have in common. It is the high average efficiency which makes a great people, and it should be the constant care and purpose of the community to bring up to the standard those who are below it.

These and similar facts constitute the fundamental basis of the work of the members of the Society, and no member who desires to keep abreast of the times in automotive matters should fail to attend the coming Winter Meeting of the Society, to be held in New York, Feb. 4-6, during the week of the Automobile Show. Many timely papers treating of vitally important subjects will be considered. Not only will the best authors available on each subject be secured, but every effort will be made to have discussion by others well versed in the arts concerned. The Meeting Committee especially desires that members come prepared to present precise and forceful discussion of the various papers to be presented at the four technical sessions of the Society, to be held on Feb. 5 and 6.

Fuel Situation to Be Treated Fully

THERE are few subjects of more pressing importance today than that of engine fuel. It should not be thought that the signing of the armistice has brought the end of the fuel problem. The Bureau of Oil Conservation of the U. S. Fuel Administration has enlisted the active cooperation of the Society in the solution of the continuing problem and is assisting in arrangements for valuable papers on many phases of the subject. A letter recently received from the United States Fuel Administration contained the following momentous statement: "We feel that the automotive industry has grown more rapidly than the country's capacity to provide gasoline and that a period of adjustment lies ahead which may prove disastrous if adequate steps are not taken in advance to meet the situation." Under these circumstances it is the duty of every automotive engineer to be informed upon the subject. Less than 25 per cent of the petroleum underground reaches the pipe line. Papers arranged for in this connection will probably include the following:

1 General summary of the situation with particular reference to the need for improving the thermal efficiency of automotive engines. By President C. F. Kettering.

2 The Unmined Supply of Petroleum in the United States. By Dr. David White, chief geologist of the U. S. Geological Survey.

3 The Status of Refinery Practice in the United States, with Special Reference to Engine Fuel. By Dr. E. W. Dean of the U. S. Bureau of Mines.

4 The Present Status of Engine Efficiency in the United States. By Dr. H. C. Dickinson of the U. S. Bureau of Standards.

5 An Interpretation of the Engine Fuel Problem. By Dr. Joseph E. Pogue of the Bureau of Oil Conservation, U. S. Fuel Administration.

6 The New "Liberty" Engine Fuel. By Major O. B. Zimmerman, Engineer Corps, U. S. A.

It is planned to devote one entire session to consideration of the fuel problem, and the members can be assured that the subject will be treated in a concise and thorough as well as extremely interesting fashion.

Aeronautic Subjects Important

ONE who imagines that the aircraft industry will largely disappear with the ending of the war will find himself in disagreement with many well qualified to express opinions on the subject. The

aircraft industry is here to stay, and many engineers will be required for the solution of pressing problems before this industry. Among these are the production of lighter, less expensive and more reliable as well as more efficient aircraft engines. Certain phases of this subject are considered in the paper on Fixed-Cylinder Radial-Type Air-Cooled Engines, by John W. Smith, which appears in this issue of THE JOURNAL. Other phases of the subject will be dealt with in another article by J. G. Vincent, formerly lieutenant-colonel and chief of the airplane engineering division of the Bureau of Aircraft Production. Mr. Vincent will give us a great deal of valuable information regarding the Liberty engine, from both historical and engineering standpoints. He is now, of course, in a much better position to give full particulars than he was at the last winter meeting of the Society, when the Liberty engine was relatively new, and had not yet been placed in quantity production and military restrictions were in force. No member will wish to miss the information to be gathered from the presentation of this paper. A paper on Proportioning Airplanes to their Engines is now in progress of preparation by an author whose name will be announced later.

The Meetings Committee has been assured also of the cooperation of the engineers of the Navy Department in furnishing information of value on navy aircraft. The data expected from this source include particulars regarding both heavier-than-air and lighter-than-air machines.

Commander F. G. Coburn of the Naval Aircraft Factory will present a paper on aircraft production. Other men of prominence identified with the various bureaus of the Navy Department have been invited and tentatively agreed to speak on Dirigibles, Airplane Engineering, and Operation of Naval Aircraft.

Other papers on aircraft subjects are expected.

Automobiles Again an Important Factor

THE slowing down of the automobile industry during the war has not, we are sure, resulted in relaxation of effort by the automobile engineer. Several very timely and important papers on automobile subjects have been arranged for. One of these will be by Henry M. Crane on the Effect of Aeronautic Practice on Automobile Design and Construction. High-efficiency engines will be the subject of a timely paper which D. McCall White is preparing. Few subjects of greater importance now confront the automobile engineer, and few are so well qualified to speak upon it as Mr. White. The importance of developing higher efficiency engines cannot be too strongly emphasized and no progressive engineer will wish to miss this valuable paper. A paper on Better Truck Performance is expected from Major Arthur B. Browne, who has been for nearly two years closely associated in development work on Government war trucks. A. Ludlow Clayden, recently returned from Europe, will present a short paper forecasting future development in the production of lighter and more efficient cars. This is a subject which every automobile engineer will have to consider in the near future, if he has not already given it extended study. There are many diverse opinions, and a special effort will be made to have the matter discussed from every angle. J. G. Utz, formerly chief engineer of the Motor Transport Division of the Quartermaster's Corps, is preparing the story of the U. S. Standard Truck, in the development of which he played a large part.

Other papers on automobile subjects, such as the economic use of trailers with trucks and the organization of base repair shops for truck maintenance, are scheduled.

Tractor Subjects

AT least four papers on tractor subjects are now in preparation. One of these will deal with fundamentals in the design of the farm tractor. Another, by Lieut.-Col. W. G. Wall, will describe fully the design and application of tractors and other automotive apparatus to the work of the Ordnance Department during the war. Lieut.-Col. Alden, past president of the Society, will present a paper describing the tanks designed and produced under his direction by the Ordnance Department, and a similar paper on British tanks by G. W. Watson of the Institution of Automobile Engineers has been promised. These papers will be of rare interest in that they will probably make public for the first time a number of the engineering features of this new type of automotive war apparatus, from which many lessons have doubtless been learned that can be applied in commercial pursuits. Every tractor engineer will wish to hear these matters discussed. Numerous members not heretofore connected with the design of tractors are becoming more and more interested in tractor engineering. It is an increasingly important phase of automotive engineering from a surprising number of standpoints.

Other Automotive Fields to Be Covered

STEPS are being taken to cover thoroughly other automotive engineering fields. Papers on motor boats and their engines, and on other phases of engineering in the marine field are being arranged for. Papers on farm and stationary engines are also in contemplation, as are others on fuel-injection engines, motorcycles and materials of engineering. Some fundamentally valuable papers on metallurgical subjects will be included in the program, if possible.

Social Features Not Overlooked

THE meeting is not to be confined entirely to engineering matters. The largest dinner in the history of the Society will be held in the ballroom of the Hotel Astor, which accommodates nearly 50 per cent more than could be seated at any previous S. A. E. dinner held in New York. Prominent speakers from the automotive industries, as well as other men of importance, have agreed to present messages which no member can afford to miss.

The Meetings Committee appreciates fully the value of social features in connection with the meeting. They enable members to become better acquainted and for other reasons are very much worth while. Many members have expressed a desire to have the meeting include sessions in which ladies will be interested. Some of these and others have felt that arrangements should again be made for attending one of the midnight shows in New York, as was done following the meeting of 1917.

With these facts in mind, the Committee is planning to arrange for the evening of Wednesday, Feb. 5, a reception to which all members and their wives will be invited. One feature of the reception is expected to be a popular lecture on some topic of the day in connection with which there will be some unusual motion pictures. It is planned that this meeting shall be followed by a dance for the members and their guests. The exact time and place at which these events will be held will be announced in the near future.

Another Midnight Frolic

Arrangements have been made with the management of the "Century Grove," the roof of the New Century Theater, for securing, on the evening of Feb. 6, the entire seating capacity available for the show known as "The Midnight Whirl." This show begins at 11:30, and is similar in general nature to the Midnight Frolic enjoyed by so many members in January, 1917. The seating capacity of the house is larger, however, so that there should be less congestion. Approximately 800 seats are available, and a large percentage of the members who attend the dinner are expected to be present at the Midnight Whirl, which will follow it. During this function there will be opportunity for dancing. Members should fill out and return immediately the blanks that will be forwarded to them for the purpose of making reservations for both dinner and Midnight Whirl. Ladies will not attend the dinner, but will be welcomed at the Midnight Whirl.

If you have not reserved your dinner as well as your hotel accommodations, *now* is the time to act. The Meetings Committee will not undertake to make hotel reservations for the members.

The Test of Ability

The test of ability to recover from the war and regain a state of normal or "abnormally great" prosperity, lies in the capacity to produce a flow of goods for trade and to supply the wants of the population. It is not a question of how much money has been expended on the war, or of the size of the national debt. It is a question of production; in our case how much automotive product our members are going to bring to the market. The facilities for production and distribution being as great as ever, there is no real obstacle in the way of prosperity. Essential factors in the adequate equipment of the automotive engineer are up-to-date information bearing upon his professional procedure, the keeping alive of his contact and friendship with fellow workers, and participation in the most important engineering and industrial events in his field. The coming meeting of the Society will be *par excellence* one of these occasions.

Show Tickets for Members

Through the kindness of the New York Automobile Dealers' Association, under whose auspices the New York Automobile Shows will be held, members who apply *in person* at the New York office of the Society will receive two complimentary tickets for each week of the shows; first week, Passenger Car Show Feb. 3-9, second week, Truck Show, Feb. 10-17.

REPORT OF DECEMBER COUNCIL MEETING

AT the meeting of the Council held Dec. 11, president C. F. Kettering, vice-president Charles M. Manly, past-president G. W. Dunham, councillors B. B. Bachman and C. S. Crawford, and treasurer C. B. Whittelsey were present. Discussion was had of the program of the 1919 Annual Meeting of the Society, to be held in New York, Feb. 4-6, during the time of the passenger-car show in Madison Square Garden. It was the feeling that an endeavor should be made to have presented papers treating all branches of the automotive field, emphasis being placed on papers forecasting future developments and serving to give a better conception of the engineering problems to be met by the automotive industries, rather than to enlarge upon war developments. (A partial outline of the program of the meeting is given in this issue of THE JOURNAL.)

The Membership Committee report included an explanation of procedure in the membership increase work, the substance of the result of the activity being that applications for membership in the Society have been received at the rate of about five a day during the last several weeks. Nearly 900 applications for membership have been received during this calendar year, as compared with something under 1400 during 1917. The percentage of applicants who qualified as members was, however, 84 and 72 per cent for 1918 and 1917 respectively. The total membership of the Society, including affiliate member representatives and enrolled students, but not Section associates, was 3780 on Dec. 1, 1918, as compared with 3063 on Dec. 1, 1917.

Three hundred and thirteen applicants were approved for various grades of membership, and one for student enrollment.

The following transfers of membership were made:

Associate to Member Grade S. R. Bennett, E. T. Boland, H. E. Brunner, O. L. Curtis, C. Ross Holmes, C. T. Klug, Walter M. Petty, E. M. Sutherland.

Junior to Member Grade Proctor Brevard, E. S. Locke, W. P. Loudon, George H. Pettit.

The following changes in affiliate member representation were made:

Bijur Motor Appliance Co. has withdrawn the name of Edward Lyndon from its list of representatives; the J. I. Case Plow Works has substituted D. C. Reeves in place of Earl L. Woods; the Eisemann Magneto Co. has withdrawn the name of F. Neef and substituted that of P. G. Sedley; Findeisen & Kropf Mfg. Co. has withdrawn the following: E. A. Rossow, W. A. Robbins, N. H. Motsinger, Jr., O. F. Kropf and C. W. Findeisen; the New Way Motor Co. has withdrawn B. V. Moore and Henry Switzgable; Timken-Detroit Axle Co. has substituted Roy G. Boechler instead of E. V. Elconin; Toro Motor Co. has substituted P. E. Wickstrow and O. O. Clapper for John E. McNally and M. E. White.

It was reported that Part I of the 1918 Transactions will probably be distributed among the members early in the year, and that the Publication Committee is considering approximately twenty-five papers for inclusion in Part II of the 1918 Transactions.

The following subjects were assigned to the Standards Committee:

AERONAUTIC DIVISION

Important
Eye Bolts.
Protective Coatings for Metal.
Radiator Hose Specification.
Streamline Wire.
Swedged Wire Ends.
Wood—Tests and Specifications.
Round High-Strength Steel Wire (Renewed).
Future Consideration
Gas Tank Blow-Off Valves.
Hand-Hole Covers for Seaplane Floats.
Map Case.
Marking Electric Wiring.
Propeller-Hub Rating.
Rudder Fittings.

BALL AND ROLLER BEARINGS DIVISION

Important
Annular Thrust Ball Bearings.
Sheave Pulley Bearings (Airplane).

CHAIN DIVISION

Important
Roller Chain Lengths and Sprocket Tolerances.

ELECTRIC VEHICLE DIVISION

Important
Rating of Vehicle Motors.

ELECTRICAL EQUIPMENT DIVISION

Future Consideration
Starting Batteries for Airplanes.
Specification for Insulated Wire and Charging Cable.

ENGINE DIVISION

Important
S. A. E. Engine Testing Form for Kerosene Engines.
(This subject is proposed as desirable to eliminate inconclusive tests of kerosene-burning equipment and to accomplish the same ends for kerosene that the present S. A. E. engine testing forms do for gasoline.)
Future Consideration
Piston-Pin Diameters.
(This subject was proposed as desirable for standardization in its application to various internal-combustion engine pistons.)

IRON AND STEEL DIVISION

Important
Aeronautic Steel Alloys.
Future Consideration
Finish of Sheet Steel.

MARINE DIVISION

Important
Fixed Port-Lights.
Swing Port-Lights.
(A sub-division has been working on these specifications and has already proposed tentative swing port-light drawings.)
Future Consideration
Shaft Couplings—Carrying Capacity.
Fittings for Fuel-Pipe Lines.
Air-Pump Bases.

MISCELLANEOUS DIVISION

Important
Carbureter Hot-Air Intake Sizes.
(A sub-division is already working on this subject.)
Future Consideration
Exhaust Pipes.
Brake Equipment.
(Parts of brake equipment desirable for standardization to be determined by the Miscellaneous Division.)
Front Ends for Automobile Side Rails.
Rear Spring Hanger Rivet Spacings.
(These subjects are practically an extension of the existing Recommended Practice shown on S. A. E. data sheets 18, 18a and 18b, Passenger Car Frames.)

MOTORCYCLE DIVISION

Future Consideration
Rear Wheel Hubs.

SPLINE FITTINGS DIVISION

Future Consideration
Review of Shaft-End.

STATIONARY AND FARM ENGINE DIVISION

Future Consideration
Screws, Studs, Nuts and Lock Washers.
Simplified Series of Stationary Engine Sizes.
(These subjects have had preliminary consideration.)

TIRE AND RIM DIVISION

Important
Solid Rubber Tires for Farm Tractors.
(This subject was proposed in the belief that considerable demand will presently have to be met, and if the tires can be standardized before each maker gets into production on his own sizes, the standard will be that much more valuable.)
Solid Tire Sizes.
(The Division is already considering this subject, following action by the War Service Committee of the Rubber Industry.)

TRACTOR DIVISION

Important
Fuel and Lubrication Pipe Lines.
Future Consideration
Gear Teeth.
Punching of Driving-Wheels.

TRANSMISSION DIVISION

Important
Universal Hub Joint.
(This subject is proposed in the belief that it will decrease the cost of production, increase sales and permit interchangeability of all accessories attached to the universal joint.)
Future Consideration
Tire Pump—Transmission Mounting.
Rear Transmission Bearings and Oil Retainer.
(This subject is considered desirable to allow all accessories to be interchangeable on the transmission.)

The following appointments to Standard Committee Divisions were made:

Berne Nadall, Miscellaneous Division.
Lieut.-Col. V. E. Clark, Aeronautic Division.
Wayne H. Worthington, Tractor Division.

With regard to the work of the Fuel and Lubricant Division, it was agreed that one of the most useful things it can do is to compile a bibliography of lubrication with special reference to internal-combustion engines and testing of lubricants and information useful to automotive engineers on the subject of fuel for internal-combustion engines. The Division is seeking to correlate research work being undertaken on this subject.

A report of the Sections Committee recommended unanimously that the petition of members of the Society residing in Washington to form a Section there be approved.

President Kettering was appointed to represent the Society on the Advisory Committee of the Engineering Division of the National Research Council. It is considered very desirable that the cooperation of research men and engineers which has been brought about during the war should be continued so that research information accumulated can be properly recorded and classified.

The Council authorized the securing of additional floor space for the offices of the Society in New York.

Engineering Division of the Motor Transport Corps

AN automotive engineering department that is responsible for more than 100 different vehicles of all types and sizes must necessarily be organized so as to handle a broad range of subjects, and in war especially it must be sufficiently flexible to take care of any and all emergency demands. The Engineering Division of the Motor Transport Corps is an engineering department that fulfills these requirements. When the armistice was signed the Division was cooperating in the engineering work of hundreds of different manufacturers of motor vehicles and of the parts, equipment and accessories making up such vehicles. The organization was supervisory in its functions as regards the outside manufacturers, and producing as regards the design and specifications of the Class B truck and other Government equipment.

INTRODUCTION

BY JOHN YOUNGER

THE engineering work of the Army's road transportation involves practically the technical work of the whole industry and its ramifications, from the largest truck down to the smallest accessory.

Much was accomplished and developed, new ideas were evolved in the stress of the times; opportunity was given to try out technical ideas in a broad way.

In the belief that much of this work will be of value to the industry as a whole, the Engineering Division, Motor Transport Corps, has prepared a series of papers dealing with its various activities, and it is planned to present these to S. A. E. members for the benefit of the industry.

The vehicles under the supervision of the Motor Transport Corps, and for which its Engineering Division has been responsible, are used in the most diverse fields of military activity. The heavy engineer trucks used for carrying supplies to construct all sorts of military works are necessarily attached to the advance guard of the combatant units. These include carpenter, blacksmith and similar trucks, and caisson, timber and heavy machinery trailers. When the engineers have finished their preliminary work, sterilizer and bacteriological vehicles of the Medical Corps step in to insure proper military conditions for the troops. The supplies are brought up in many different types of motor vehicles, ammunition in the four-wheel-drive trucks, food and other supplies in the Class B and smaller transport vehicles. Hot rations for the men are carried close to the front line trenches in the rolling-kitchen trailers, motor or animal-drawn. Water is brought up in the large 1000-gal. tank trucks and distributed in smaller vehicles of 180-gal. capacity. The service of relief, as the Medical Corps with its motor equipment may be called, consists of the light and heavy ambulances, mobile hospitals carrying medical supplies or operating equipment, x-ray vehicles, and de-gassing outfits.

The Ordnance, Signal and Aviation branches of the army all require highly specialized motor-driven vehicles. Portable machine-gun units, reconnaissance trucks, artillery repair vehicles, anti-aircraft motor vehicles—all these are used by the Ordnance Department. The Signal Corps trucks are fitted with field lighting sets, wireless equipment, and with machine-shop bodies. The Aviation Section has been using the regular light and heavy aviation trucks and trailers, and also many special trailers for carrying planes, propellers, engine test equipment, pigeon lofts and photographic equipment. The passenger-carrying vehicles are an important factor in carrying on the work at the front. These consist of light, medium and heavy passenger cars, Ford, Dodge and Cadillac, and Indian or Harley-Davidson solo motorcycles, and motorcycles with side-cars. Bicycles of the military model are also used to a considerable extent.

This brief outline will show the variety of the problems which have had to be solved by the engineers of the Motor Transport Corps and of the other branches of the army that have in the past handled motor vehicle engineering work. All this work has now been concentrated in the Motor Transport Corps. The Engineering Division consists in part of the former Engineering Section of the Motor Transport Service, Quartermaster Corps, and also of personnel transferred from the motor vehicle engineering divisions of other branches of the service. The Quartermaster Corps engineering organization was described in the September, October, November and December, 1917, issues of THE JOURNAL. When the committees began work in Washington on the Class B military truck the engineering personnel was attached to the Engineering Department of the Motor Transport Division, Quartermaster Corps; later it was part of the Production Section, Office of the Quartermaster General, and finally became the Engineering Section of the Motor Transport Service, Quartermaster Corps. The next step was to its present status as the Engineering Division, Motor Transport Corps.

FUNCTIONS OF THE ENGINEERING DIVISION

The main function of the Engineering Division is to provide designs and specifications for Motor Transport Corps vehicles. These vehicles include all motor-driven road apparatus in use by the army, with the exception of the tanks and tractors, the engineering work of which is handled by the Ordnance Department. The Division is continually investigating the value of motor vehicles, bodies and other equipment for military purposes. Suggestions in regard to changes in existing designs are received from overseas or from sources in this country, and are investigated with a view to improving design or remedying any defects that may have developed. While the Engineering Division does not make any investigation of new inventions, it works in close cooperation with the Inventions Section of the General Staff, which has a special organization for investigating new ideas and inventions pertaining to military motor transport.

All the activities of the Division are under the direct supervision of the Chief, who reports directly to the Chief of the Motor Transport Corps.

The Division consists of three branches, Executive, Planning and Technical Service. All the design, drafting and testing work is handled by the Executive Branch. The Planning Branch has general administrative functions, collects information, and prepares specifications. The Technical Service Branch maintains contact with the training, maintenance and operations work being conducted by the Motor Transport Corps.

The Executive Branch is divided into three sections, Experimental and Testing at Camp Holabird, Md., and the Engineering and Design, and Records at Washington. The Experimental and Testing Section carries on all the road tests and experimental work necessary to determine the adaptability to military use of complete vehicles and equipment. The work includes the road testing of motor vehicles and mechanical and electrical laboratory testing, extensive facilities being provided for the latter. Considerable testing for the Engineering Division has been carried on from the Motor Transport Corps shops at Fort Sam Houston, Texas, where more severe road tests can be made than on the roads surrounding Baltimore.

In the Engineering and Design Section all new designs of motor vehicles and accessories are prepared, as are also the parts lists needed to get designs actually into production. The engineering work is so extensive that it has been found necessary to subdivide it to a considerable extent, and separate engineers are assigned to the different standardized vehicles, such as the B, TT, A and AA, and to such specialized subjects as bodies, trailers, touring cars, motorcycles and bicycles and accessories and standards.

The third part of the Executive Branch is the Records Section, which has charge of the distribution of specifications, blueprints and parts lists of vehicles. This information is supplied through the Motors and Vehicles Branch of the office of the Director of Purchase and Storage to the contractors making the different vehicles or parts. In the same way the Records Section informs these contractors of changes made in the drawings or parts lists. This section also prepares and distributes the lists of repair parts, catalogs and instruction books of vehicles operated by the Motor Transport Corps.

The Planning Branch is attached to the office of the Chief of the Engineering Division. Its Projects Section gathers data from the different divisions of the army in regard to new types of vehicles. The technical requirements are then determined and turned over to the Engineering and Design Section for the preparation of drawings and parts lists. The Projects Section also handles all overseas letters and cables dealing with motor vehicle engineering matters.

The function of the Statistical Section is to conduct interviews, handle routine correspondence, maintain statistical records showing the progress of the work in different parts of the Engineering Division, collate reports of discoveries, supervise the catalog files and library, and maintain records of all work undertaken by the Division.

The Specification Section supplements the work of the Engineering and Design Section. As a matter of fact, the complete specifications may be considered to include the drawings and parts lists prepared by the Design Section, and also the statement of special requirements ordinarily referred to as "specifications," and prepared by the Specification Section.

These specifications have been prepared for the purpose of giving information which could not be placed on the drawings. Complete specifications were made for each major vehicle, for all important units, and in many cases for individual materials or articles required in the construction of military vehicles or for their maintenance after they were placed in service.

Many and Varied Specifications Prepared

Specifications have been prepared during the past year for Class B, A, AA, AT and TT military trucks, as well as for a large number of more unusual types of vehicle, such as transport wagons for carrying horses; de-gassing outfits for furnishing hot shower baths to soldiers who have been in gas attacks; kitchen trailers for carrying hot rations or food supplies; and other special vehicles built in accordance with changing war needs.

The specification work has been done with the fundamental belief that no untried devices should be placed on military vehicles, and that every part or attachment should be so built as to be equal in strength, workmanship and durability to every other part of the vehicle. All new ideas and untried devices were referred to the Inventions Section of the General Staff, which made a careful study of them, conducted tests of promising devices, and recommended to the Engineering Division those which were proved of value.

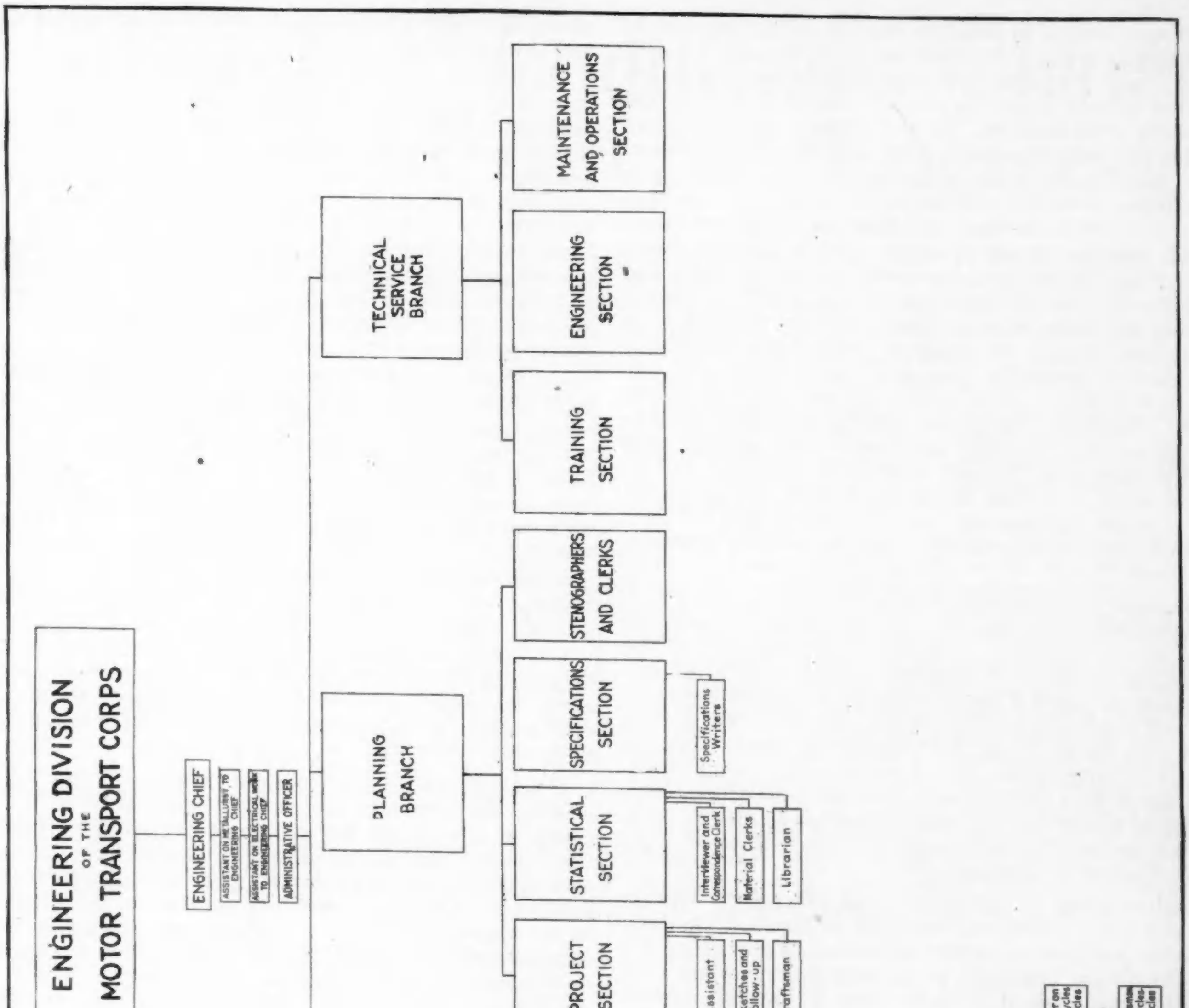
In connection with the preparation of specifications a large number of conferences have been held from time to time with engineers of outside companies specializing on various products. The parts submitted were also subjected to severe laboratory and road tests, and the specifications formulated after a study of the manufacturing problems involved and of the service requirements. It was sometimes difficult to secure cooperative effort on account of the desire to supply regular commercial products, but with such cooperation specifications have been produced that have been of distinct advantage not only to the Government but also to the automobile industry as a whole. As an example, the specifications prepared by the Engineering Division for solid and pneumatic tires may be mentioned.

From the time the war started many devices were brought to the attention of the Division, these being in the nature of equipment or special attachments for motor vehicles. The Government's policy of restricting materials to essential industries greatly increased the number of such devices that were proposed. Some of them fulfilled their maker's claims, while others did not, but it was as necessary to keep to the settled program with reference to specifying approved accessories as it was with the major parts of the car.

After the new ideas and untried devices had been referred to the Inventions Section of the General Staff there were still left many accessories which had been made in a small way for a considerable time. Everything strange and unusual for the Ford and other passenger cars used by the Government was offered, but these cars were standardized as bought from their makers, the position being taken that each vehicle had demonstrated beyond a doubt that it was a successful product, and that a difference of opinion regarding details of construction should be adjudged in favor of the maker. This put at a disadvantage some meritorious accessories, but on the other hand rendered unnecessary the making of use-major vehicle, for all important units, and in many cases less experiments at a time when cars and not theories were wanted.

Better Accessories Produced

The energies of the Engineering Division have resulted in the production of accessories that are considerably in advance of those on the market previously. Skid chains,


ENGINEERING DIVISION OF THE MOTOR TRANSPORT CORPS
ENGINEERING CHIEF
ASSISTANT ON METALLURGY TO ENGINEERING CHIEF
ASSISTANT ON ELECTRICAL WORK TO ENGINEERING CHIEF
ADMINISTRATIVE OFFICER
EXECUTIVE BRANCH
PLANNING BRANCH
TECHNICAL SERVICE BRANCH
EXPERIMENTAL AND TESTING SECTION
ENGINEERING AND DESIGN SECTION
RECORDS SECTION
PROJECT SECTION
STATISTICAL SECTION
SPECIFICATIONS SECTION
STENOGRAPHERS AND CLERKS
TRAINING SECTION
ENGINEERING SECTION
MAINTENANCE AND OPERATIONS SECTION
Road Test
Trucks and Cars
Motorcycles & Bicycles
Truck Co. No. 445
Laboratory and Bench Test
General Testing
Electrical Testing
Repair Shop
Stock
Office Administration
Property
Civilian Personnel
Enlisted Personnel
Messengers and Clerks
Distribution of Blue Prints & Specifications
Parts Lists
Tracing Files
Print Distribution
Blue Prints
Files
Specifications
Overseas Letters
Outside Blue Prints
Repair Parts Catalogues & Instruction Books
Repair Parts Catalogues
Instruction Books
Retouching
Assistant
Sketches and Follow-up
Draftsman
Interviewer and Correspondence Clerk
Material Clerks
Librarian
Specifications Writers
CHIEF DRAFTSMAN
Engineer on Accessories and Standards
Chief of Tabulations and Standards
Engineer on Bodies
Chief Draftsman Bodies
Engineer on Trailers
Chief Draftsman on Trailers
Head Checkers
Engineer on B-Truck
Chief Draftsman on B-Truck
Engineer on TT-AT Trucks
Chief Draftsman on TT-AT Trucks
Engineer on Touring Cars
Chief Draftsman on Touring Cars
Engineer on A-AA Trucks
Chief Draftsman on A-Trucks
Chief Draftsman on AA-Trucks
Engineer on Motorcycles and Bicycles
Chief Draftsman on Motorcycles and Bicycles

horns and lamps, to mention specific instances, had to be adapted to the particular needs of the service, and in all cases the manufacturers readily cooperated to produce quality where price had theretofore been the dominant consideration. Before the war, truck makers had bought steering-wheels from almost any source, and these had usually given satisfaction, but when trucks were driven overland, and parked in all kinds of weather, and even when on the docks awaiting shipment, trouble occurred, and new types of wheel rims had to be developed. Two distinct rims were evolved, one of wood and the other of wood impregnated with a substance having the characteristics of a synthetic resin. The wood rims early demonstrated the need of using waterproof glue only, and of arranging the wood parts so that expansion due to atmospheric action did not tear the joints apart. Obtaining the proper coating to resist weather and wear was another problem. The second type of wheel rim went through a series of changes until it, too, emerged in a new form, reinforced throughout so that it could not open up in the seams as had its competitor in the race to produce a good motor truck steering-wheel rim.

The parking of numbers of cars in the open where they are subjected to low temperature, has brought about need for a heater that can be conveniently attached to the circulating system and generate enough heat to protect the radiator. Such a heater must be of rugged construction and independent of electrical sources. The present protection, by draining the circulating system, has its obvious disadvantages, and a satisfactory heating element would be a distinct gain if it can be produced. No successful heater has yet been presented to fill the need, and the problem is big enough to suggest some real endeavor toward its solution.

Another group of accessories was not always readily susceptible to mechanical, chemical or physical analysis. Electrical energizers, carbon removers, chemicals or devices to obtain more power or decreased gasoline consumption, were found in many cases to have the claims made for them based on psychological reactions of the car driver or the manufacturer of the devices and not at all on the facts. Such devices were grouped, and as far as possible authoritative tests made of the fundamental claims of each group. A typical example can be cited in the tests made in conjunction with the Inventions Section, General Staff, and the Bureau of Standards, to determine the value of water in the combustion chamber, in all its possible applications by vapor, steam, actual liquid injection through the manifold, the air intake, and above or below the piston. The results on the whole showed that there was practically no effect from such water injection.

Work of the Technical Service Branch

The Technical Service Branch has been organized on the principle that after the planning work is done, the designs completed, and the vehicles and the equipment produced, there should be an organization in the Engineering Division to follow up the vehicles in their particular work.

The Technical Service Branch is divided into three sections, one (Training) dealing with the education of personnel. Drivers for Motor Transport Corps vehicles are recruited from the ranks, and a close contact must be had with them so that the average level of intelligence can be gaged; also so that technical questions which are taken up relating to design or construction can be handled authoritatively.

The second section (Engineering) maintains close contact with the actual operation of vehicles. Vehicles are designed usually for specific purposes. It is necessary, therefore, to see that in their operation the Design Branch has taken care of all the desired features, and that it is also kept in touch with any improvements that may be suggested as a result of different methods of operation. This section has a number of officers in contact with the various operating divisions. These men circulate around and obtain information by observation, by conference with the motor transport officers and with the officers operating the vehicles.

The third section (Maintenance and Operation) maintains close contact with the maintenance and repair depots or service parks. This is probably the most important section of the three, and it is here that the mistakes of the Design Branch are shown up. Parts that could be materially improved, and wrong designs all show up under service and again by observation and by conference with the maintenance officers, the proper information is collected and transmitted to the Design Branch for action, thus tending to a constant improvement in the quality of the Motor Transport Corps equipment.

The Technical Service Branch is also responsible for keeping in touch with the work of other nations as regards the use of motor transport equipment, and in general acts as the Intelligence Branch of the Engineering Division.

The personnel of the different sections of the Engineering Division has necessarily been drawn from the plants of a large number of companies making automotive vehicles and parts. Early in the war the greater part of these men patriotically gave up their work and devoted all their experience and energies to the military motor transport program. When the armistice was signed nearly 200 engineers, draftsmen, testers and necessary executive and clerical assistants were engaged in the Engineering Division work. The majority of these men were working at Washington, but there were also forces of from twenty to thirty at Jersey City, N. J. (design and experimental work on Class AT and TT trucks), at Cleveland, Ohio (design and drafting work on Class A truck), at Detroit, Mich. (design and drafting work on Class AA truck), and at Camp Holabird, Md., where the testing laboratory of the Division is located.

Motor transportation has been of such predominant importance in the recent war that it will be necessary to go on developing and making experiments with improved types of motor vehicles. It seems, therefore, that the future activities of the Engineering Division will embrace not only the technical questions that come up regarding the present equipment of the Motor Transport Corps, but cover also new developments. Because of its public status the Division can act as a stimulus to all motor truck engineering through its efforts to create improved vehicles for military purposes.

Only general activities of the Engineering Division have been described in this first article. It is hoped, however, in later issues of THE JOURNAL to present more detailed discussions of specific problems of design, drafting room and records practice, testing and research, and other technical work of the Division. It is expected that a paper describing the research work done to determine the value of water injection will be submitted to the Society at a later date.

Carbureting Conditions Characteristic of Aircraft Engines*

TESTS have been conducted at the altitude laboratory of the Bureau of Standards to determine the changes in engine performance with changes in atmospheric temperature and pressure at various levels above the earth's surface, with special reference to the

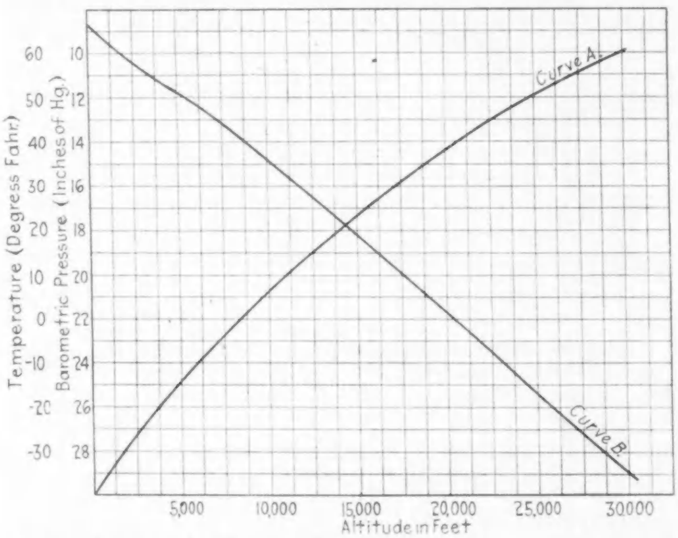


FIG. 1—PRESSURE-ALTITUDE (CURVE A) AND TEMPERATURE-ALTITUDE (CURVE B) CURVES

The first is plotted from the equation

$$\text{Altitude in feet} = 62{,}900 \log_{10} \frac{29.9}{\text{Pressure in inches of mercury}}$$

The second is the average for the year.

variables affecting the functioning of the carbureter and the changes in performance resulting from variables in the carbureter itself. This work has resulted in the following conclusions:

1 Mixture ratio (air to fuel) should be constant at all pressure levels, for maximum power at all levels.

2 Change in viscosity of fuel with temperature change is an important metering characteristic of the carbureter.

3 Unwarranted waste of fuel is invariably involved in the use of carbureters not fully corrected for barometric changes.

4 Heating of the mixture causes a loss in power output, accompanied by an increase in the consumption of fuel, at least with such fuels as are available for war purposes.

All of the tests from which the following material is taken were made in the altitude laboratory at the Bureau of Standards, employing a 150-hp. Hispano-Suiza type A engine, having eight cylinders in blocks of four, set at 90 deg. The cylinders had a bore of 120 mm. (4.73 in.), a stroke of 130 mm. (5.124 in.) and a compression ratio (total volume over clearance volume) of 5.3. A constant speed of 1500 r.p.m., the speed of maximum mean effective pressures, was maintained throughout the runs.

It is known that the values of the air readings used in the following plottings are somewhat high; and for this reason it is pointed out that the results, including air to fuel ratios for the mixtures, should be employed qualitatively rather than quantitatively, though the results are in perfect agreement among themselves.

Curve *A*, Fig. 1, shows the relation existing between the altitude, measured in feet above sea level, and barometric pressure; and curve *B* gives the same information for the mean annual temperature and altitude in feet above sea level.

Fig. 2 brings out the engine pumping capacity in pounds of air per hr. per 100 cu. ft. of piston displacement, with open throttle, at different barometric pressures. The points on this curve are means of a great many measurements using a carbureter capable of giving maximum output over the whole range of pressures; and, while the readings are known to be high, as noted in the introduction, the characteristic is quite definitely established. It will be noted that the curve quite pronouncedly turns upward as the pressure becomes less. This follows from the fact that the pressure-drop to cause air to flow at constant velocity is less with lesser density, thereby permitting the aspiration of proportionately greater volumes of air as the density value lowers. The graph, Fig. 3, showing manifold pressure-drop plotted against barometric pressure, in this case car-

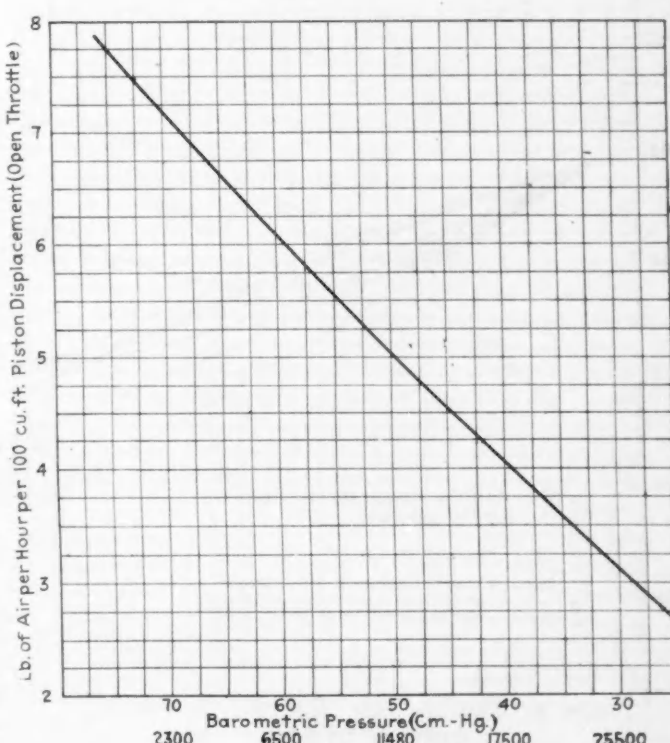


FIG. 2—PUMPING CAPACITY—PRESSURE CURVE OF 150 HP. HISPANO-SUIZA ENGINE OPERATING WITH OPEN THROTTLE AT 1500 RPM

*From Bureau of Standards report No. 10 on aeronautic power-plants.

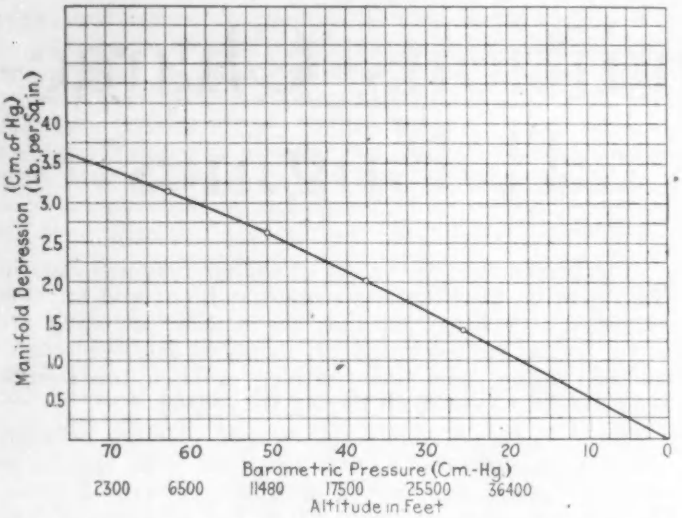


FIG. 3—CURVE SHOWING RELATION BETWEEN MANIFOLD PRESSURE-DROP AND BAROMETRIC PRESSURE

bureter inlet pressure, is characteristic of the variation in pressure-drop to cause air to flow in the intake system with changes in atmospheric density.

Fig. 4 shows the consumption of gasoline of 0.7350 sp. gr. per hr. per 100 cu. ft. piston displacement, with open throttle, plotted against barometric pressure. The fuel used in these tests is described by the fractionation curve of Fig. 5. In Fig. 4 is shown the manner in which conventional carbureters, designed for compensation in the ordinary sense at ground level, cause enrichment of the mixture with lowered atmospheric pressure. Curve *a* is from tests of a device having a manual control re-

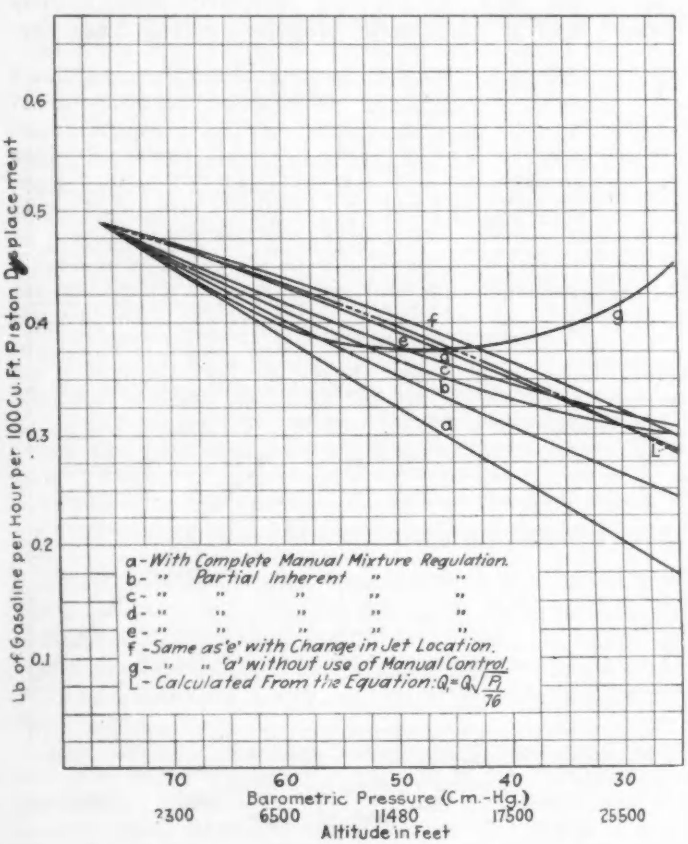


FIG. 4—FUEL METERING CHARACTERISTICS OF SEVERAL CARBURETERS WITH OPEN THROTTLE AT 1500 RPM

set to give greatest power output at each barometric level. Curves *b*, *c*, *d* and *e* are results with several carbureters inherently embodying a measure of correction for enrichment with lowered density. Curve *L* is calculated from the equation

$$Q_1 = Q\sqrt{\frac{P_1}{76}}$$

in which Q is the quantity of fuel discharged at sea level and Q_1 is the quantity of fuel discharged at any other level, corresponding to the pressure P_1. This equation assumes a constant value for the coefficient in the equation

$$V = C\sqrt{2\,gh}$$

for the fuel metering passage. Curve *g*, Fig. 4, is that for carbureter *a*, but with ground setting of the manual control at all barometric levels. The great waste of fuel

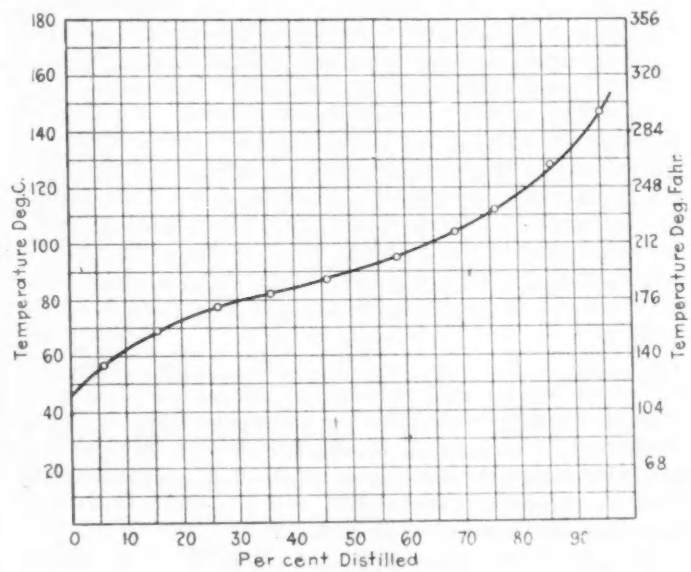


FIG. 5—FRACTIONAL DISTILLATION CURVE OF GASOLINE USED IN MAKING THE TESTS DESCRIBED

resulting from the use of a carbureter uncompensated for wide barometric changes is obvious from the diagram, particularly when it is considered together with that of Fig. 6, wherein are given the brake mean effective pressures corresponding with the two rates of fuel consumption presented in curves *a* and *d* of Fig. 4.

The observed enrichments, expressed as percentage excess fuel in the mixture, for the several cases of Fig. 4, are plotted in Fig. 7, against barometric pressure.

The considerable variations among the curves of Figs. 4 and 7 are largely the result of variations in the extent to which change in viscosity of the fuel with temperature enters the results. No two of the several carbureters used in these tests have identically proportioned fuel-metering passages; hence it is to be expected that differences will be apparent among the results, considering them from this viewpoint alone.

In Fig. 6, showing the maximum brake mean effective pressure plotted against barometric pressure, it is seen that no justification can be found for the fuel consumption rate of curve *d*, Fig. 4. Not only is fuel wasted at all levels and power lost above 14,000 ft. altitude, but the mixtures are so rich at the greatest altitudes as to cause fouling of spark-plugs and combustion chamber walls.

In Fig. 8 are presented the relationships between brake mean effective pressure and mixture ratio, with the lat-

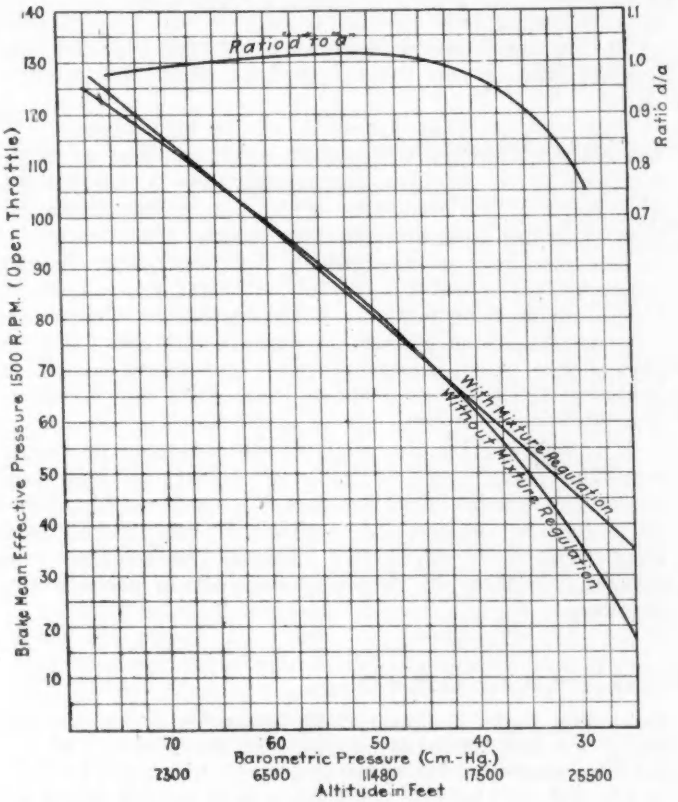


FIG. 6—CURVES OF BRAKE MEAN EFFECTIVE PRESSURE AND ALTITUDE BASED ON CURVES *a* AND *d*, FIG. 4

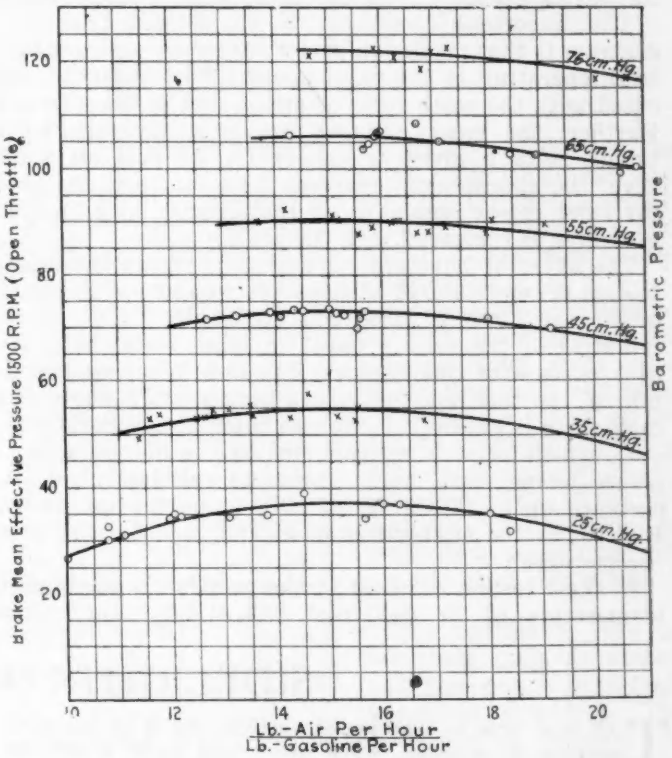


FIG. 8—CURVE OF RELATIONSHIPS BETWEEN BRAKE MEAN EFFECTIVE PRESSURE AND MIXTURE RATIO AT VARIOUS ATMOSPHERIC PRESSURES

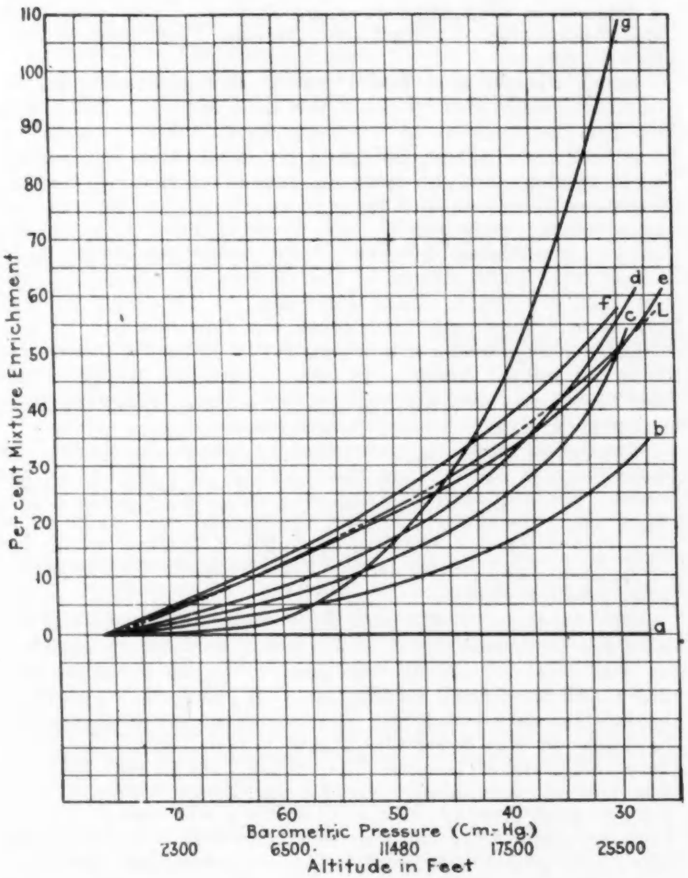


FIG. 7—MIXTURE ENRICHMENT CHARACTERISTICS OF THE SEVERAL CARBURETERS GIVEN IN FIG. 4 PLOTTED AGAINST BAROMETRIC PRESSURES

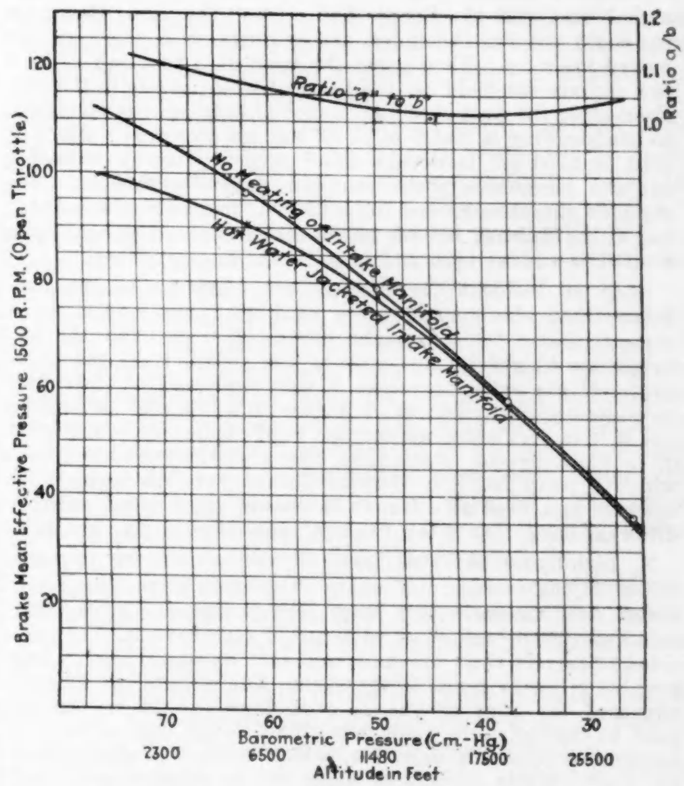


FIG. 9—CURVE SHOWING EFFECT OF HOT-WATER JACKETING OF THE INTAKE MANIFOLD OF A 150-HP. HISPANO-SUIZA ENGINE
The curves from top to bottom are referred to in the text as *c*, *a* and *b*

ter varied through wide limits at each pressure level.

The important conclusion to be reached from this diagram is that maximum power output at each pressure level, operating at the rated speed of the engine, is secured with the same ratio of air to fuel in the mixture. Further, the mean cylinder pressures decrease more rapidly with a given change in the air-fuel ratio the lower the atmospheric pressure. This points to the need for much closer regulation of the mixture with lowered pressures as compared with the higher.

The effect of hot-water jacketing of the intake manifold on the engine used is shown for two sets of test runs in diagram, Fig. 9, these two tests being fairly representative of the results found in other tests that have been made with this engine. The loss following jacketing of the manifold branching immediately above the carbureter is greatest at the maximum atmospheric pressure, which latter is accompanied by the highest atmospheric temperature, and becomes of relatively less importance up to 17,000 ft. altitude (note the top curve, Fig. 9), as the atmospheric pressures and temperatures become lower.

In these tests a constant intake manifold water-jacket temperature of 37 deg. cent. (96.8 deg. fahr.) was maintained. In such a case the pumping loss in the engine following heating of the mixture will vary directly with the temperature difference between mixture and jacket; and in an inverse manner with the mixture density.

This assumes that the whole of the heat given up by the constant-temperature water-jacket appears as sensible heat in the mixture. Of course, this is not realized, since some of the heat taken up by the mixture is used to evaporate the fuel, and becomes latent. The proportion of the total heat received which is so used depends upon so many variables, considering different fuels and different carbureting methods, that it is impossible to state the two results in general terms. In any case, the net result only is of importance and its characteristic, as found in these tests, is shown clearly by the curves of Fig. 9.

It is noteworthy also that, in general, loss in output resulting from manifold hot-water jacketing is accompanied by greater fuel consumption values, regardless of carbureter design and method of control; and with fixed adjustment carbureter designs the economy loss following heating in this way may attain serious proportions.

SIDELIGHTS ON AIR COMBATS

THE best time to take aerial photographs is in the early morning or evening, when everything casts a shadow. Then, for instance, if a big gun is covered with camouflage so that from directly above it looks like the ground around it, the shadow which it must cast will betray it. The Boche machines came over the lines almost constantly during these two periods of the day, and though anti-aircraft guns were after them every minute.

All of a sudden a machine gun toward the front would signal back that the Boches had crossed the line. Generally we could not see them, but the gunners with their glasses picked them up. Then came the bark of a gun and after a few seconds we could see the burst of white smoke in the sky. Even after the first shot you cannot always see the machines, as the shooting is likely to be off and an airplane in flight at 4000 or 5000 yd. is a very small target. But by following out the successive shots you can generally find it. The machine flies along, ducking and twisting until the aviator has either finished his job or the fire becomes too hot, when he makes a short turn and beats it for his own lines.

Such an incident does not arouse much enthusiasm because when the machines are so high there is not much chance of one being brought down. You can tell the approximate height by the color of the smoke from the shots fired. If the enemy machine is very high and far away we have to use shrapnel, which makes a white puff of smoke, but if it is very close we can use high explosives, which give off a black smoke. Each kind has a distinctive sound also which is very hard to describe but easy to distinguish. A machine gun fired at a target in the air has a sound entirely different from that when fired at something on the ground.

A high-flying machine generally furnishes the curtain-raiser of the evening and every evening is about the same, except that the main acts vary. The Boches had been firing on a cross road back of us with rather poor results. They decided to correct their mistakes and sent an observation plane over very low to regulate the shots. The minute the aviator appeared the guns opened up with high explosives, but he paid no attention to them except to dodge and twist and continue toward his objective, which was some distance to the rear. While he was in sight of the roads a couple of shells landed on them; so he must have been able to take some good pictures.

When a French fighting machine swooped down to attack him some of the finest maneuvering I ever expect to see began. The Boche had everything against him, his machine was slower and harder to manage than the Spad and he was far from home and below his opponent. But the fellow was an ace and kept turning in circles, always getting nearer his own lines and at the same time preventing the Frenchman from getting "on his tail," which would have been fatal. The two kept circling around like this for fully 5 min., exchanging a few shots with apparently no results. Then the Boche had reached his own lines and the lone Frenchman did not dare to follow.

Some French and Boche patrol fighting machines encountered each other at about the same altitude. They were too far away for us to tell them apart. All we could see was first one machine diving on one lower than it, then another coming straight down on one under him. Often one flyer would dive on another only to straighten out when he got near and could see the Iron Cross or Tricard on the machine. Sometimes, however, they would exchange shots. There were about fifteen in the combat, all doing the wildest kind of stunts. They kept this up for about 10 min. and then divided into two groups and flew home.

Later a Frenchman saw a lone Boche below him, dove and fired but missed cleanly. It was so dark the tracer bullets the Frenchmen used showed up like balls of fire, giving the same general effect as a Roman candle.

Two Boche machines came over low, under the clouds. One came for our balloon and the other for one further to the right. The anti-aircraft guns cut loose, but he was too low for them. We thought he had the balloon sure when all of a sudden he opened fire from a couple of hundred yards and then ducked and turned back. French patrols had appeared and he had to beat it.

Two Spads went after him full speed. One was right behind him and gaining while the other went off at an angle to head him off. Finally the Boche saw he could not get away and he dipped suddenly and turned back. The Spad behind him dove and fired. The Boche was cornered and had to fight. It was wonderful the way they turned and dove, doing all sorts of things. They must have passed within a few feet of each other. Finally, the Boche having started a long spiral dive, one of the Frenchmen who was above him came straight down on him and that was the final blow. The Boche glided down, with both Frenchmen right after him and firing. Just before he disappeared from our view over the hill we saw his machine burst into flames.

—*F. R. Perley*

Bureau of Standards' Report on "Liberty" Fuel

The so-called Liberty fuel is the result of a series of experiments the purpose of which was to produce a substitute less costly than liquid gasoline but capable of convenient use in gasoline engines. Precise information regarding its composition is not yet available but it is understood that the ingredients are approximately 80 per cent kerosene and 20 per cent benzol or some other coal tar product such as toluol. It is said that these two substances are chemically combined and form a fuel which is odorless, readily volatilized, non-corrosive and non-carbonizing.

The products of combustion are also said to be odorless and cooler than those of gasoline. The cost of manufacture is reported as being 40 per cent lower than that of gasoline. Some light is thrown upon the performance of engines using the fuel by the summary of the official Bureau of Standards report here given. More particulars in this regard are promised in a paper on Liberty fuel by Major O. B. Zimmerman of the Engineer Corps, U. S. A., who is in part responsible for the development of the fuel.

IN accordance with the request of the General Engineer Depot of the United States Army, the Bureau of Standards has made laboratory tests of a gasoline substitute prepared by Capt. E. C. Weisgerber.

The fuels were prepared from materials and by processes the specifications for which the Bureau understands are in the possession of the General Engineer Depot, but which have not been communicated to the Bureau of Standards.

Three grades of the fuel were submitted for test, labeled motor fuel Type A, motor fuel Type B, and Liberty fuel. The first two fuels named were designated as automobile and motor truck fuels and the last named fuel was designated as an aviation engine fuel.

The tests made on the fuels submitted were of two distinct types: (1) Tests to determine those physical characteristics of the fuels which have bearing on their use in automobile and airplane engines; (2) Tests to determine the comparative performance of engines when using the fuels submitted, and when using representative grades of motor truck gasoline and aviation gasoline.

The physical characteristics which were determined for the fuels submitted, and for the representative fuels with which they were compared are: (1) The "total" (high) and "net" (low) heating values; (2) The specific gravities; (3) The distillation temperature characteristics.

Engine Tests

The engine tests were made on two engines designed for widely different types of service. The two fuels, motor fuel Type A, and motor fuel Type B, were tested in a U. S. A. standardized Class B truck engine, and were compared with a representative grade of commercial gasoline that is covered by the United States General Supply Committee Specification for 1918.

The "Liberty" fuel was tested in a 150-hp. Type A Hispano-Suiza engine fitted with high-compression (5.3:1) pistons, and manufactured by the Wright-Martin Aircraft Corporation, New Brunswick, N. J. The Liberty fuel was compared with a representative grade of aviation gasoline fulfilling specification No. 3512 of the Bureau of Aircraft Production for export aviation gasoline. This gasoline was distilled from Pennsylvania crudes by the Atlantic Refining Company, Philadelphia.

Laboratory Tests

The heating values of the fuels were determined at the Bureau of Standards from a series of careful calorimetric determinations in a Junker's calorimeter. In table 1 the "total" (high) and "net" (low) heating values are given in B.t.u. per lb. for the three fuels submitted, and also for the "Commercial" G. S. C. 1918 gasoline, and the U. S. Standard export aviation gasoline.

The specific gravities of the fuels submitted and the representative fuels with which they were compared are given in terms of the density of water at 60 deg. fahr. and in the corresponding values of degrees Baumé. The weights of the fuels in pounds per gallon are given for comparison.

The distillation data on the three fuels submitted, and the comparison fuels are given in table 3. The distillations were made at the Bureau of Standards in accordance with the method developed by the Bureau of Mines, and described in the Bureau of Mines Technical Paper No. 166, entitled "Motor Gasoline" (Properties, Laboratory Methods of Testing and Practical Specifications) by E. W. Dean.

When a sample of the Liberty fuel was cooled to 10 deg. cent. (+ 14 deg. fahr.), it was found that a considerable amount of crystallization had occurred. This fact shows that the fuel as submitted cannot be cooled much below this temperature without serious danger of stoppage in fuel lines and carbureter jets.

The engine performance tests on the motor fuel Type A, and the motor fuel Type B were made in a U. S. A. standardized Class B truck engine, coupled to a 125-hp. Sprague electric dynamometer. This engine is of the four-cylinder four-cycle water-cooled type, with 4.75-in. bore and 6-in. stroke. The carbureter is non-adjustable. The spark advance is adjustable.

In this series of tests, runs were made at maximum power, one-half maximum power and one-quarter maximum power. During each run at a fixed load rating successive readings were taken on the test fuel and on commercial gasoline at each 200 r.p.m. from 400 to 1200 r.p.m. The entire run was then repeated as a check. The loads for the half and quarter-power runs were determined from the readings at wide-open throttle. The entire series of runs on the Type A fuel was completed before the runs on the Type B fuel were started.

During the tests no trouble of any kind was experienced in operating the engine with these fuels. The exhaust was clean, odorless, and not appreciably different from that of gasoline.

The results of this series of tests indicate that the power developed by the two test fuels is in all respects equal to that developed by commercial gasoline.

The pounds of fuel consumed per brake-horsepower-hour of the two substitute fuels averages about 3 per cent greater than in the case of commercial gasoline.

The gallons of fuel consumed per brake-horsepower-

hour of both substitute fuels averages about 5 per cent less than that of commercial gasoline.

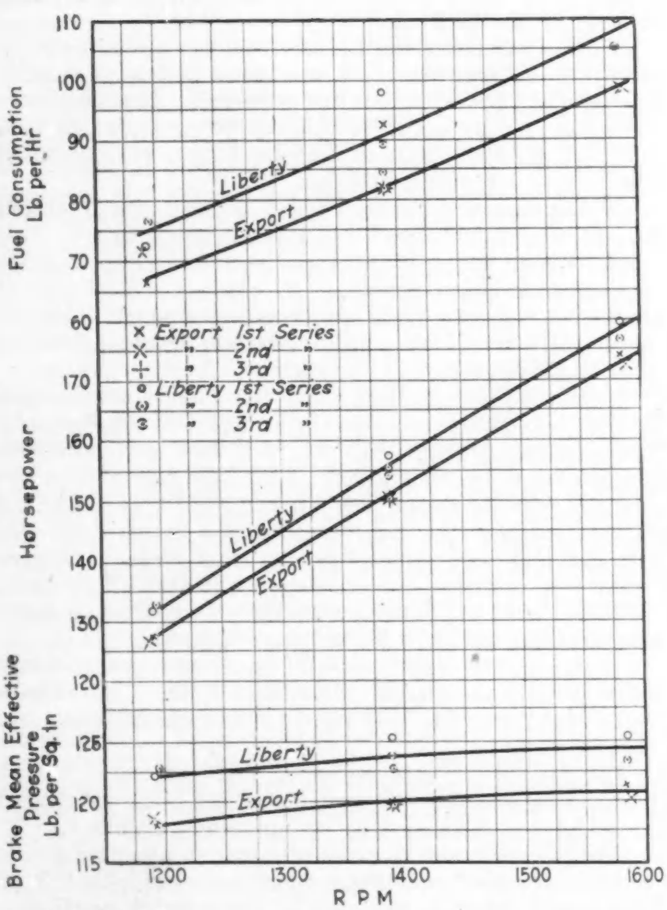
In the comparative engine performance tests on the aviation engine, three series of observations were taken. In the first two series 5-min. runs were made at 1200, 1400 and 1600 r.p.m. In the third series of runs the engine was operated at one speed, 1400 r.p.m., for about 1 hr. and 20 min. on each fuel. During this test oil samples were taken every 20 min. In all three series of tests the engine was operated at wide-open throttle, and as nearly as possible under constant conditions of oil temperature, oil pressure, water-jacket outlet temperature

TABLE 1—HEATING VALUES OF FUELS TESTED

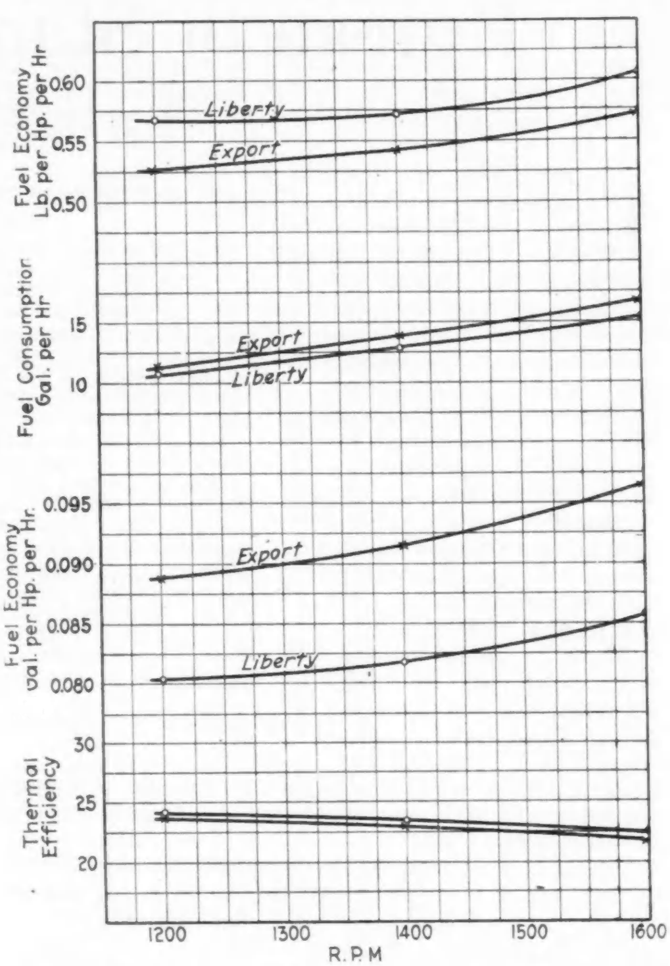
Fuel	Total B.t.u. per lb.	Heating value B.t.u. per U. S. gal.	Net B.t.u. per lb.	Heating value B.t.u. per U. S. gal.
Motor Fuel, Type A..	18,540	133,300	17,590	126,300
Motor Fuel, Type B..	18,760	135,000	17,770	127,900
Liberty Fuel	18,599	131,200	17,680	124,800
Commercial G.S.C. 1918	20,200	128,000	18,810	119,200
Export Aviation	20,320	120,600	18,940	112,300

TABLE 2—SPECIFIC GRAVITY OF FUELS TESTED

Fuel	Specific Gravity 60 deg. fahr.	Degrees Baumé	Lb. of fuel for U. S. gal. at 60 deg. cent.
Motor Fuel, Type A.......	0.862	32.7	7.19
Motor Fuel, Type B.......	0.863	32.2	7.20
Liberty Fuel	0.848	35.0	7.07
Commercial A Fuel........	0.728	62.1	6.08
G.S.C. 1918 B Fuel........	0.752	56.2	6.33
Export Aviation	0.711	66.9	5.93



RESULTS OF THREE SERIES OF FUEL COMPARISON TESTS OF LIBERTY FUEL AND EXPORT GASOLINE WITH A 150-HP. HISPANO-SUIZA ENGINE



COMPANION OF LIBERTY FUEL AND EXPORT GASOLINE AS FUEL IN A 150-HP. HISPANO-SUIZA ENGINE

TABLE 3—FUEL DISTILLATION DATA

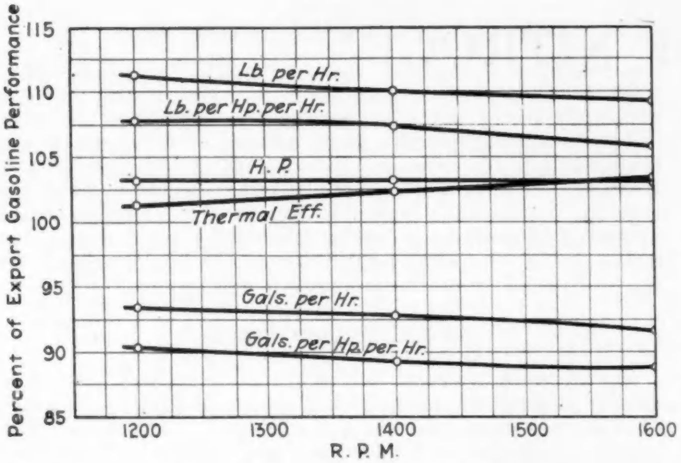
Initial	Motor Type A deg. C.	Motor Type B deg. C.	Lib. Fuel deg. C.	Comm. G.S.C. 1918 deg. C.	Export Aviation deg. C.
Boiling Point..	78	78	77	...	50
10 per cent....	81	80	79	...	70
20 per cent....	82	81	80	50 to	73
30 per cent....	82	81	81	105	78
40 per cent....	84	82	82	...	82
50 per cent....	85	83	83	140	87
60 per cent....	87	89	86	...	91
70 per cent....	89	95	94	...	97
80 per cent....	173	214	173	...	104
90 per cent....	222	243	221	175	115
95 per cent....	244	278	260	...	130
Dry Point.....	244	285	260	210	158
Per cent....	95	97	95	...	98
Residue, per cent	2.0	1.5	1.8	...	1.3
Loss, per cent.	3.0	1.5	3.2	...	0.7

TABLE 4—FUEL COMPARISON TEST

"Liberty" Fuel and "Export" Gasoline, Observed Data

Series I

Fuel.........	"Export" Gasoline			"Liberty" Fuel		
R.p.m.	1,191.0	1,389.0	1,585.0	1,191.0	1,389.0	1,585.0
Brake Mean Effective Pressure, lb. per sq. in.	118.5	120.2	121.4	122.2	125.1	125.1
Lb. per hr...	66.7	92.1	95.2	72.3	97.9	109.7
Hp.	127.8	150.8	174.3	131.9	157.3	179.7



PERFORMANCE OF LIBERTY FUEL IN PERCENT OF EXPORT GASOLINE PERFORMANCE

Series II

Fuel	"Export" Gasoline			"Liberty" Fuel		
R.p.m.	1,188.0	1,390.0	1,588.0	1,194.0	1,388.0	1,583.0
Brake Mean Effective Pressure, lb. per sq. in.	118.1	119.6	120.3	122.6	123.7	123.2
Lb. per hr...	71.4	81.9	98.5	76.7	84.6	105.3
Hp.	127.0	150.3	172.7	132.3	155.3	176.8

Series III

Fuel	"Export" Gasoline			"Liberty" Fuel		
R.p.m.	1,389.0	....	....	1,389.0	....	....
Brake Mean Effective Pressure, lb. per sq. in.	119.6	....	....	122.8	....	....
Lb. per hr...	81.5	....	....	89.1	....	....
Hp.	150.2	....	....	154.3	....	....

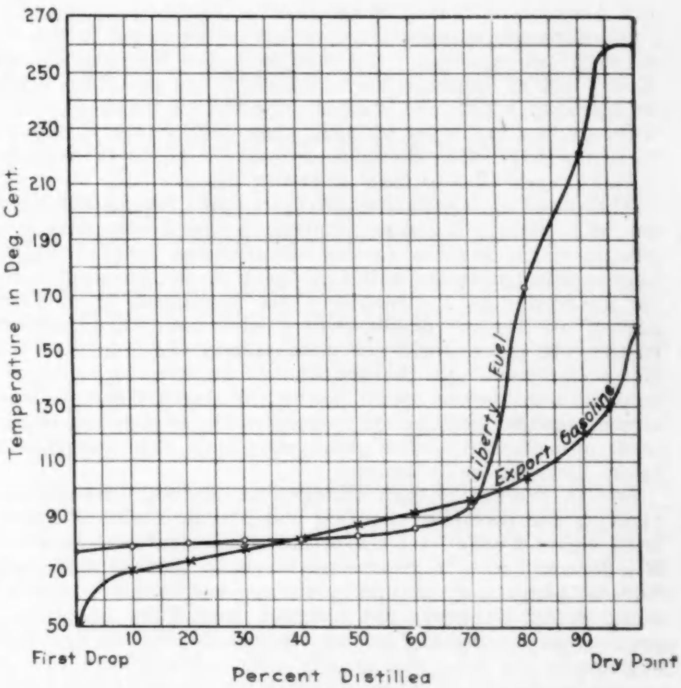
and carbureter air-inlet temperature. The engine was fitted with a Claudel carbureter which is constructed so that the air to fuel ratio can be varied at will from the control board. Before all runs the fuel mixture was adjusted to give maximum power with the lowest fuel consumption possible. The spark advance was fixed at 20 deg. The spark-plugs were cleaned, and the gaps adjusted before each run.

In the second series a revolution-counter was used to check the speed, as indicated by the tachometer.

Two readings were made of speed, torque, temperatures, etc., during each run at each engine speed. The average of the observations at each speed is given in table 4. The revolution-counter was read each minute for a total of 5 min., and showed that the speed was fairly constant throughout each run.

The object of the third series of runs was to determine if the use of "Liberty" fuel would dilute the lubricating oil more than standard "Export" gasoline. Before starting this series of runs the engine was "warmed up" and drained of all oil. Then the pump was allowed to draw about 2 gal. of fresh oil through the engine. After the system had drained thoroughly, 3.5 gal. of Wolf's Head No. 8 oil was put in. After the engine had been idling for a few minutes a sample of the oil was drawn off. During the test, samples of oil were drawn off every 20 min. until five samples were obtained.

Before starting these tests new spark-plugs were put in for the run on Export gasoline, and then fresh plugs were used for the run on the Liberty fuel. The plugs used in the Liberty fuel run showed a slightly greater carbon deposit than the plugs used in the run with Export gasoline.



DISTILLATION CURVES USING THE BUREAU OF MINES METHOD OF LIBERTY FUEL AND EXPORT GASOLINE

TABLE 5—FUEL COMPARISON TEST
"Liberty" Fuel and "Export" Gasoline

Data from Series I, II and III

Fuel	"Export" Gasoline		
R.p.m	1,200.	1,400.	1,600.
Brake Mean Effective Pressure, lb. per sq. in.	118.3000	120.2000	120.6000
Hp.	128.7000	152.3000	174.7000
Lb. Fuel per hr	67.8000	82.8000	100.0000
Lb. Fuel per hp.-hr	0.5270	0.5430	0.5730
U. S. gal. per hr	11.4200	13.9400	16.8600
U. S. gal. per hp.-hr	0.0888	0.0915	0.0966
Thermal Eff. (per cent)	23.8000	23.1000	21.9000
Fuel	**"Liberty" Fuel**		
R.p.m.	1,200.	1,400.	1,600
Brake Mean Effective Pressure, lb. per sq. in.	122.2000	123.8000	124.4000
Hp.	132.8000	157.0000	180.2000
Lb. Fuel per hr	75.4000	91.5000	109.2000
Lb. Fuel per hp.-hr	0.5680	0.5830	0.6060
U. S. gal. per hr	10.6700	12.9300	15.4300
U. S. gal. per hp.-hr	0.0803	0.0817	0.0857
Thermal Eff. (per cent)	24.1000	23.5000	22.6000

The results of tests in an aviation engine indicate that Liberty fuel, compared with a gasoline fulfilling the export specification for aviation gasoline, will develop about 3 per cent greater horsepower when consuming 10 per cent greater weight of fuel per horsepower per hour. The thermal efficiency of the engine when using Liberty fuel is, however, about 2 per cent greater than it is when using the export grade of gasoline.

FIXATION OF NITROGEN

THE fixation of atmospheric nitrogen has been realized in an experimental way in the United States. The largest water-power development in the world for the fixation of nitrogen from the atmosphere is being undertaken in northern Alabama on Muscle Shoals.

Throughout the ages nitrogen has accumulated in the soil through two agencies. One has been the lightning's flash. Every bolt of lightning burns the air in its path into oxides of nitrogen which are washed into the earth by the rain. Through the centuries millions upon millions of strokes of lightning have been doing their part to supply the plants with nitrogen vital to their existence and growth.

The other agency taking nitrogen from the air for plant use is a minute organism clinging to the roots of certain plants, which has the faculty of grasping hold of atmospheric nitrogen in the soil and fixing it on the plant roots for absorption by the plant. These organisms, in numbers beyond all human comprehension, have done their part to sustain the plant world and consequently the animal world. Not many years ago the artificial propagation of these organisms was worked out to success. Today the use of these nitrogen-gathering bacteria is common in the planting of the seeds of such leguminous plants as alfalfa, the clovers, soy beans, cowpeas and peanuts.

But to procure enough nitrogen in the soil through the planting and continued planting and turning under of inoculated legumes calls for a use of land that is often impossible. If a farmer had a large acreage of cheap land he might afford to plant and continue planting cowpeas and turning them under to supply the nitrogen needed by succeeding grain crops, grains and cotton drawing heavily on nitrogen supplies in the soil. But in only a few sections can such a system be worked and then insufficiently. It has become evident, with higher priced land, more intensive cultivation and the steady increase in the consuming population, that the lightning's flash and the nitrifying organisms are not sufficient to sustain the plant life of this country and Europe.

Already the scarcity of nitrates in the United States is serious, as any farmer will testify. The nitrate beds of Chile, our chief source of nitric acid for munitions and our main source of nitrates for fertilizer, are limited. The small quantities of nitrates that can be obtained are at virtually prohibitive prices.

Genesis of Processes

The first effort at fixation of atmospheric nitrogen was with the electric arc—the principle of the lightning's flash. This method has been a great success in Norway, where there is very cheap waterpower. The experiments in this country with this method failed for lack of cheap waterpower. Germany quickly availed herself of the discovery and prepared for the day when she should attempt the impossible. Cut off from the nitrates of Chile, Germany made ammunition by utilizing fixation of atmospheric nitrogen.

In Canada, beside Niagara Falls, a large nitrogen fixation plant was built, while this country imported from northern Europe large quantities of atmospheric nitrogen. This plant has supplied Canada and the United States with large quantities of nitric acid for munitions.

When the great war came, after a survey of the waterpower sites of the United States, the Muscle Shoals of the Tennessee River were selected as the place for an enormous plant for the fixation of atmospheric nitrogen. Meanwhile, to meet immediate needs of war, steam plants were built on the Tennessee River at Muscle Shoals.

Muscle Shoals Project

At Muscle Shoals a concrete dam, more than 100 ft. high and nearly 1 mile long, will be built between Florence and Sheffield. This will dam the waters for 16 miles. A second dam will throw back the waters for more than 50 miles. With the coupling up of a great amount of waterpower more than 500,000 hp. will be delivered at Muscle Shoals—the greatest power attained by any previous development in this country, and possibly power in excess of any similar development that could be undertaken in the United States. Here either one or two or possibly both of the new processes for the fixation of atmospheric nitrogen will be used.

The Cyanamid Process

One of these is known as the cyanamid process. The first step is putting air under high pressure at low temperature. This produces liquid air which is subjected to fractional distillation; its nitrogen and its oxygen are broken apart and each gas obtained directly in pure form. The nitrogen, thus procured is brought into contact with calcium carbide. When the nitrogen broken apart from the oxygen of liquid air, is brought into contact with calcium carbide in a retort at a fixed temperature, there is formed cyanamid—lime nitrogen. Cyanamid is a fertilizer and has been used with splendid results also. But from cyanamid, nitric acid and ammonia are obtained. With these two, obtained cheaply and in vast quantities, the possibilities are little short of dazzling.

The Haber Process

Government engineers are now making experiments with the Haber process. In this, as in the cyanamid process, liquid air is made and in the fractional distillation nitrogen is obtained. Meanwhile the electric current has decomposed water for its hydrogen. This hydrogen is brought into contact with the nitrogen from the liquid air and ammonia is obtained.

Four-fifths of the air being nitrogen, on every acre of the earth's surface there are more than 33,000 tons of nitrogen. If, each year, all the nitrogen above a suburban "farm" of only ten acres were obtained, it would amount to more than the entire importation of nitrates from Chile for fertilizers. Thus the nitrogen in the atmosphere can scarcely be touched and yet it will yield such vast quantities as to make the few hundred thousand tons we bring in every few months a mere handful.

Properties of Nitrogen

Nitrogen, as nitrogen, is a seemingly stupid, lazy gas. But in contact with certain other elements it exhibits amazing nervous energy. With other elements it results in the most delicate perfumes. But in a different atomic combination it produces fumes that are sickening. It is found deadly in such poisons as prussic acid and the ptomaines. Yet again, in different formulas, it makes possible the most healing synthetic medicines. In gunpowder, dynamite and guncotton, it is the agent of death and destruction. As lime nitrogen or ammonia it is a life-giving, growth-making fertilizer that will prevent starvation of soil and plants when the nitrate beds are gone and forgotten.

The last mentioned is the one great use to which Muscle Shoals will be put. Vast quantities of nitrogen must be supplied to our farms, east, south, and west, if food enough is to be produced indefinitely for our continued existence.

Coke supply for Muscle Shoals is at hand for the production of calcium carbide that with nitrogen forms cyanamid. But both coke and lime for the making of calcium carbide are required. In the Tennessee Valley there are deposits of lime rock that cannot be exhausted in centuries of fertilizer production. Northward in Tennessee and southward in Florida are the most extensive deposits of phosphate rock in America. Combine with this rock the ammonia secured from cyanamid and we have ammonium phosphate, a necessary constituent in all fertilizers.

Increased Food Production

The complete fertilizer contains nitrogen, phosphorus and potash. The fixation of atmospheric nitrogen, with coke, lime, and phosphate rock in abundance, will give us from the Muscle Shoals development nitrates and phosphates in hitherto unrealized quantities and cheaply. The problem of potash is yet to be solved, despite discoveries of potash in the Northwest. But the great thing is nitrogen. Second to it, and far less important, is phosphorus. Third, and of still less importance, is potash—Germany's "monopoly."

With our many waterpower sites and numerous watersheds, the fixation of atmospheric nitrogen, already begun by steam plants at Muscle Shoals, holds undreamed-of possibilities of food production for our increasing population on higher and higher priced land. Our farms are suffering and will continue to suffer until the Muscle Shoals and subsequent similar developments put atmospheric nitrogen into the soil by the millions of tons annually.

—Littell McClung, *in N. Y. Times*

THE EMPLOYMENT OF LABOR AT HOG ISLAND

At the recent annual meeting of the American Society of Mechanical Engineers, Dudley R. Kennedy* described the activities of the industrial relations department of the Hog Island yard of the American International Shipbuilding Corporation in connection with the problem of securing and maintaining a force of 35,000 employes and providing for their needs and comforts. Some of the salient features of the paper are given below:

The contract between the United States Shipping Board and the American International Shipbuilding Corporation Emergency Fleet Corporation, signed on Sept. 13, 1917, called for the construction of the largest shipyard in the world and 120 ships, to be built therein, all in twenty-one months. Seventy of the boats were to be cargo carriers of 7500 dead-weight tons and 50 boats of 8000 dead-weight tons, combination cargo and transport. The yard was to have 50 shipways, or two more than the six largest yards in America combined, with the necessary administration and service facilities to serve this number of ways properly.

Between the date of the signing of the contract and Oct. 20, 1918, some of the work accomplished included:

- 18 miles of streets and roads
- 82 miles of standard-gage ballasted railroad track
- 21 miles of water pipe
- 50 shipways requiring the major portion of the 127,000 piles driven
- 72,500 ft. of drainage ditches
- 71,350 ft. of sewage piping
- 90,000 ft. of compressed-air pipe for the second largest compressed-air plant in the world, the largest being at the Rand Mine in South Africa
- 16,300 ft. of fuel-oil pipe
- A water-supply plant from which the plant is now using daily 2,000,000 gal. of water
- 250 buildings
- 15 large restaurants and cafeterias, serving daily 12,000 to 18,000 meals
- 4 ships have been launched
- 44 are under construction
- 61,000 tons of steel have been placed in ships
- 7,000,000 rivets have been driven
- The bulk of 3,500,000 cu. yd. of material to be dredged, has been removed, and all of the divers and sundry things incidental and necessary to all this

To accomplish this, money was expended at a rate five times as great as that for the Panama Canal.

The schedule called for 11,000 men on Dec. 1, 1917, 18,000 on Jan. 1, 1918, and 25,000 on Feb. 1. This meant hiring men and building up a working force at a rate beyond anything before attempted. In October, 1918, there were on the payroll 35,000 employes, and to obtain that number and maintain the necessary interim quota it was necessary to hire over 230,000 people in the calendar year, which means a labor turnover of nearly 700 per cent.

In the month of August, 1918, the plant had 7583 accidents, of which, however, only 160 were time-losing accidents of over one day. The percentage of accidents was only 0.97 per cent of the men employed, and the infections ran 1/8 of 1 per cent, all of which compares favorably with the best records shown by the largest commercial companies in the country.

The wage setting and adjustment for the job has been a serious task, and while the U. S. Shipping Board Labor Adjustment Board has fixed a standard scale for all shipyards, covering the shipbuilding trades, the building of Hog Island presented many problems on construction rates involving almost every conceivable craft. Notwithstanding the hardships to which workmen have been subjected, and the difficulties with which the works have been beset, not one day has been lost through strike or labor difficulty. The "open-shop" has been maintained throughout and it is only justice to say here that organized labor has, in the main, lived up to its agreement with the Government in not attempting to force recognition of the "closed" shop.

Almost the universal problem with employers has been the question of securing a sufficient number of employes to operate at maximum capacity. It has been a question of collection, not of selection. There has sprung up, however, quite an array of new men. To meet the shortage of men, short "cramming" courses were instituted in several universities on employment management, and practically every branch of the Government officially recognized the necessity for their services. The danger is, however, that a really serious practical problem is likely to fall into the hands of a man of little or no practical experience, who thinks the answer lies in treatises or in books.

Commenting on general employment conditions, Mr. Kennedy said, "We have generally overlooked the human-engineering phase of our industrial development. We are facing a new order of things. Permit me the temerity to prophesy that the executive of the next decade will be the man who best knows men. He will be an organizer, a handler of men in the individual, a handler of men in the mass, a leader, not a driver, a very human man. The science of human engineering is here to stay. The study of human characteristics is the most enduring as well as the most fascinating in the world, and still the most complex. The historian and the novelist have never run out of material, and the human is their sole subject. One cannot pick men by rule of thumb, by physiognomy, phrenology or algebraic equation, still less by a set of stock test questions."

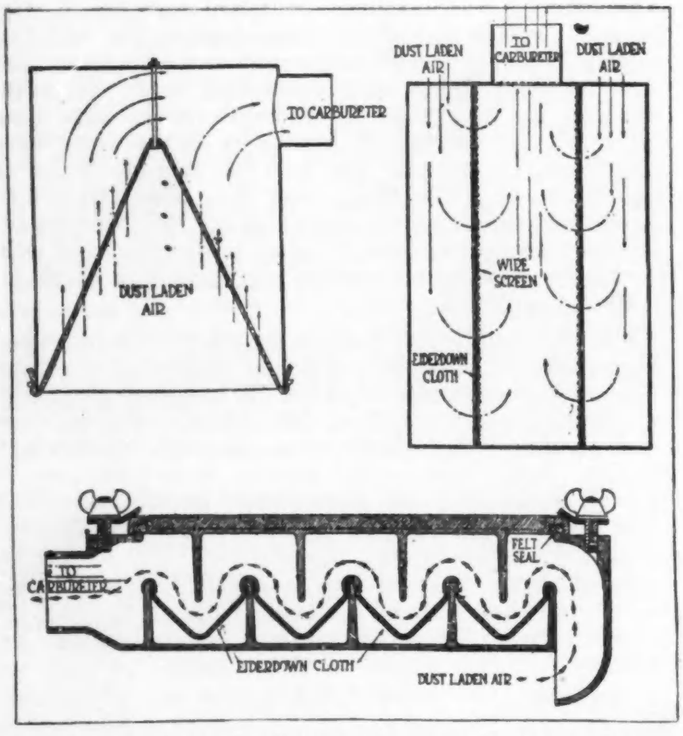
*Employment manager Hog Island shipyard, American International Shipbuilding Corporation.

Carbureter Air Cleaners

By W. G. Clark* (*Member*)

Minneapolis Section Paper *Illustrated with* **Photographs**

THE trend of engine design in the tractor and the automobile fields during the past few years has been more along the line of increased efficiency of prevailing types than toward the development of new types. This is logical in the development of a mechanism as new as the gas engine, although the demand for higher efficiency has perhaps been hastened and rendered more insistent by the war. This demand was naturally felt first by the accessory people, especially the makers of magnetos, carbureters and bearings, and the fact that it was some time before any appreciable progress was apparent showed that too much of the burden had been placed on them. It is gratifying to note that rapid progress has been made since the engine designers have cooperated by taking over their share of the work.



Figs. 1, 2 and 3—Screen Type Air Cleaners Employing Flannel or Eiderdown Cloth. The Dust-Laden Air Is Drawn Through the Cloth in the Two Upper Ones and in the Lower the Dust Is Collected on the Surface

One of the most important factors of improving efficiency and service in automotive work, was the early recognition of the fact that dirt and carbon are the worst enemies of the internal-combustion engine. Changes in design along protective lines and the application of external preventive means in the form of air cleaners, have done much toward increasing the operating efficiency and life of field engines. I think it is not necessary to discuss the need and value of an air cleaner, especially for tractor and truck engines. Fully 80 per cent of the different tractors and several trucks have air cleaners as standard equipment. The specifications of the United States Army for trucks and tractors include adequate air cleaning devices for the carbureter. The destructive effect of dirt and other incombustible mineral matter on the cylinders is well known. The air cleaner is an important part of the field equipment. Everyone who attended the National Tractor Demonstration at Salina this year will testify that the air cleaners had plenty of work to do. Pictures taken at the time give some idea of the tremendous dust clouds in which the tractors had to work.

Types of Air Cleaners

The earliest form of air cleaner was merely a fine-mesh screen of considerable area attached to the carbureter air-intake. This was used several years ago, but for obvious reasons was not very efficient or satisfactory. Another of the earlier forms of cleaner was called the "rain type," of which the modern air washer or water cleaner is a development. It was a modified form of the washers and humidifiers used for cleaning and moistening air in public buildings. The cleaning was accomplished by drawing the carbureter air through a fine film or sheet of water which flowed over a screen to a reservoir and return. It was very cumbersome and impractical for field use, although if well made it was quite effective.

There are several types of cleaner now in use on tractors and trucks, namely:

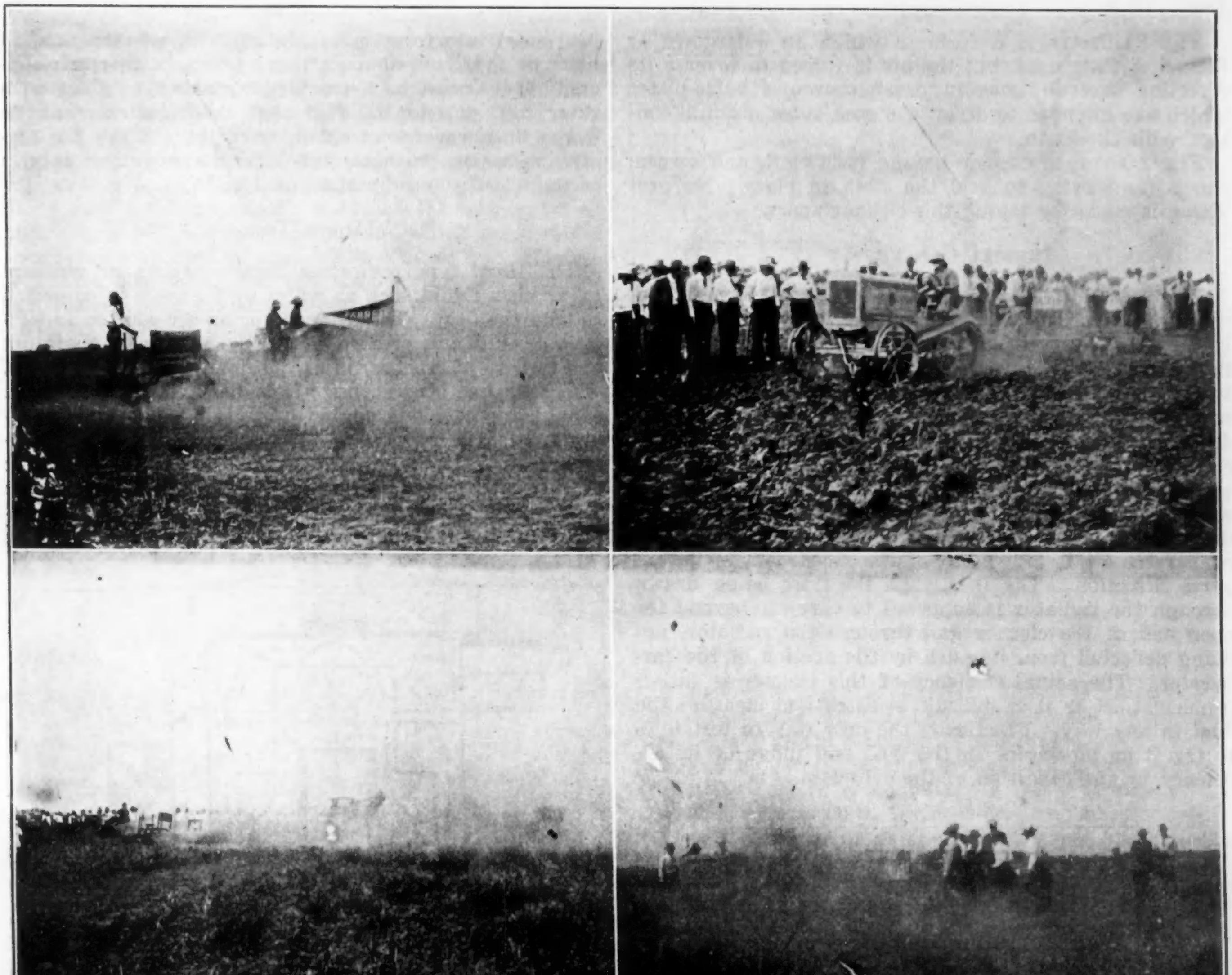
(1) Cleaners having cloths or screens or both to catch the dust,
(2) Inertia cleaners,
(3) Those in which water or some other liquid is used to wash the air, and
(4) Centrifugal or gravity cleaners.

Cloths and Screens

The first type is practically obsolete. It is troublesome, ineffective and bulky, as to clean efficiently the cloth or screen area must be very large to cut down the air velocity and yet provide any considerable capacity. Both cloth and screen soon clog and restrict the flow of air to the carbureter, thus enriching the mixture. This creates carbon and causes overheating and other kindred troubles. There have been numerous forms of this type of cleaner, of which Figs. 1, 2 and 3 are examples.

Fig. 1 shows a cylindrical drum closed at the end connected to the carbureter, and covered at the other end by an eiderdown cloth held in the shape of a cone by a wire at the top. The air is drawn upward through the cone of eiderdown and thence into the carbureter. With this cleaner the operator would have to clean the cloth very frequently in dusty field work or carry considerable cloth with him for the many changes necessary in a day's run.

*Engineer, Wilcox-Bennett Carbureter Co., Minneapolis.



SOME TYPICAL EXAMPLES OF DUST CONDITIONS ENCOUNTERED IN TRACTOR OPERATION

Fig. 2 illustrates a form in which an eiderdown or flannel cloth is used, but the air is forced to reverse its direction several times in passing around baffle-plates which are intended to direct the dust-laden air into contact with the cloth.

Fig. 3 shows a cleaner having both cloth and screen, the latter serving to hold the cloth in place. No provision is made for taking this cleaner apart.

Inertia Cleaners

The second class I have called inertia cleaners, because their action depends upon the inertia of the dust in the air to carry it out of the air-stream when the air-flow is suddenly reversed or changed before passing to the carbureter. One form of this type of cleaner, of which there are now several varieties, is shown in Fig. 4. It consists of a rectangular metal casing with one side open and a connection from the closed side to the carbureter. The open side of the casing is placed against the outside of the radiator core facing in the direction of air-flow through the radiator, so that the carbureter air is drawn out of the air-stream in the reverse direction. The inertia of the dust being drawn through the radiator is supposed to carry it beyond the open end of the cleaner and through the radiator, not being deflected from its path by the suction of the carbureter. The actual efficiency of this cleaner is rather problematical as it is difficult to catch and measure the dust in any way. Practically the only way to test it is to try it on an engine in the field and judge of its efficiency by the condition of the cylinders.

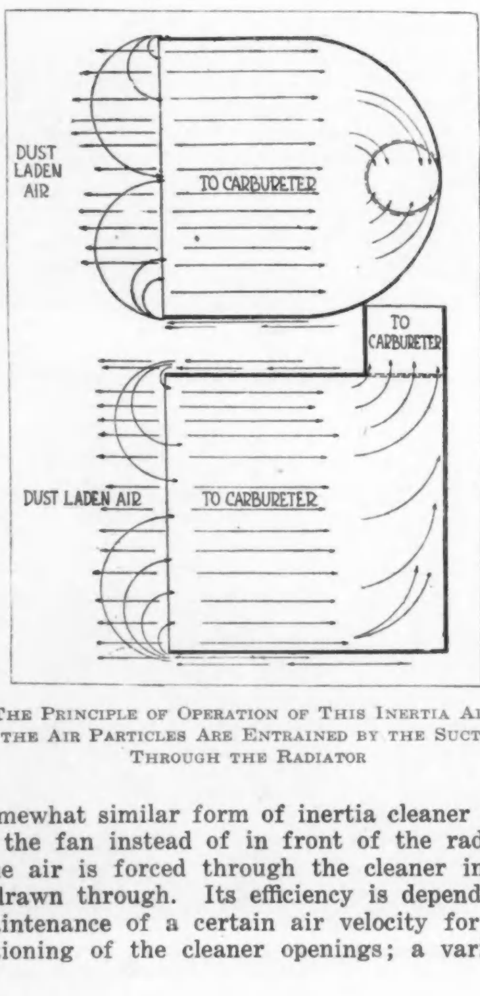


Fig. 4—The Principle of Operation of This Inertia Air Cleaner Is That the Air Particles Are Entrained by the Suction of Air Through the Radiator

A somewhat similar form of inertia cleaner is placed behind the fan instead of in front of the radiator, so that the air is forced through the cleaner instead of being drawn through. Its efficiency is dependent upon the maintenance of a certain air velocity for a given proportioning of the cleaner openings; a variation of fan speed interferes seriously with its effectiveness. I have no available data on these forms of inertia cleaners. There must be a considerable volumetric loss with their use, due to the fact that the carbureter air is drawn in a reverse direction from that of the fan air-stream, which possesses the kinetic energy and inertia of its velocity and direction of flow.

Liquid Traps

The third type comprises those cleaners or washers in which a liquid such as water or kerosene is employed to trap the dust. The demand for an air-washer or wet-type cleaner was created primarily by engine operators and owners of tractors in exceptionally dusty territories, who felt that other types of cleaners were not efficient enough for adequate engine protection. However, judging from data on most of the best air-washers and dry-type cleaners, I do not believe that the slight advantage of the wet type over the best dry types is sufficient to compensate for the extra trouble and difficulty encountered in the use and care of a wet-type cleaner. The

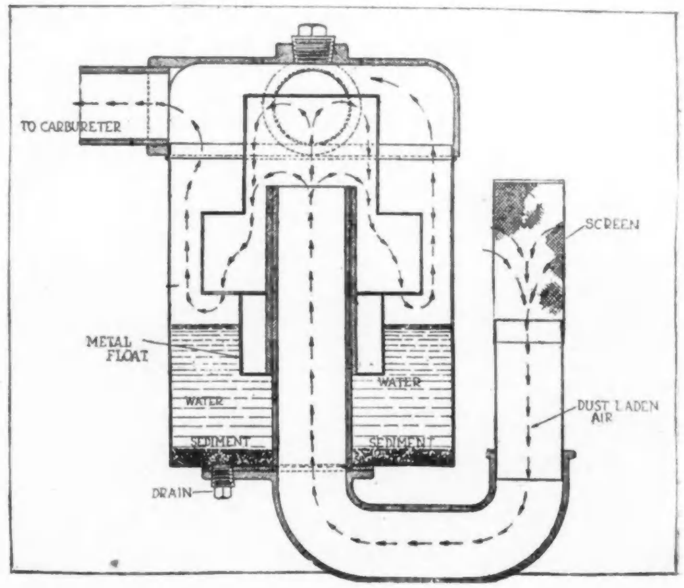


Fig. 5—In This Type of Liquid Air Cleaner the Air and the Dust Particles Strike the Water Before Entering the Carbureter

best dry-type cleaners will catch from 95 to 100 per cent of the dust passing into them, the efficiency varying with the fineness, weight and volume of the dust. Under the most adverse conditions for the dry type, the best air washers will show not more than 2 or 3 per cent better efficiency. Such conditions are most frequently encountered in some of our Western States, where the dust is largely composed of volcanic ash—lava dust. This dust is very light and fine, which makes it hard to stop. It also contains considerable vegetable matter, so that of the small percentage that escapes the dry-type cleaner, the major portion is combustible vegetable matter that will burn in the cylinders without deposit.

I think that many have been misled as to the efficiency of the air-washer by comparing it with building air-washers and humidifiers. While their action is somewhat similar, they differ in a very important respect. The ordinary building air-washer deals with air

at low velocities through which finely divided water particles are passed. The carbureter air-washer deals with air at high velocities which must be pulled through a quantity of water. In one case the surface of a large number of water particles comes in contact with a slowly moving volume of air, affording ample time, when properly designed, to wash all the air thoroughly. In the other case a volume of air is forced through water at high speed. This forms air bubbles which trap within themselves particles of dust. These never get into contact with the water and are carried through into the carbureter. The best carbureter air-washers are those in which these air bubbles are broken up and reduced to a minimum. Their presence accounts for the fact that even the best air-washers are not always 100 per cent efficient, especially under the extreme conditions mentioned. I know of two carbureter air-washers that are not as efficient as some dry-type cleaners because of this defect. Under ordinary field conditions the difference in efficiency between the wet and dry-type cleaners is very slight. I think that if the truth were known most tractor owners now using the wet-type cleaner do so on account of the moisture which these furnish to the intake air, rather than because of any really better operation. For some engines which do not cool any too well, especially when using kerosene, the heavily moistened and cool air from a water cleaner is almost as much a necessity as freedom from dust.

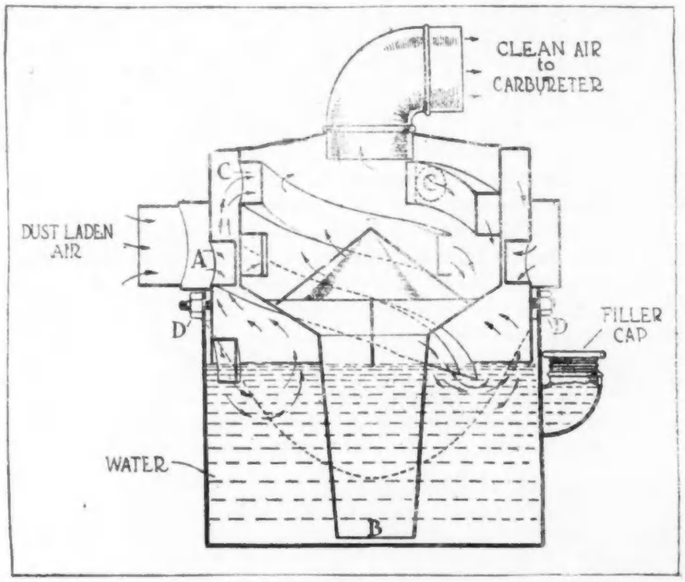
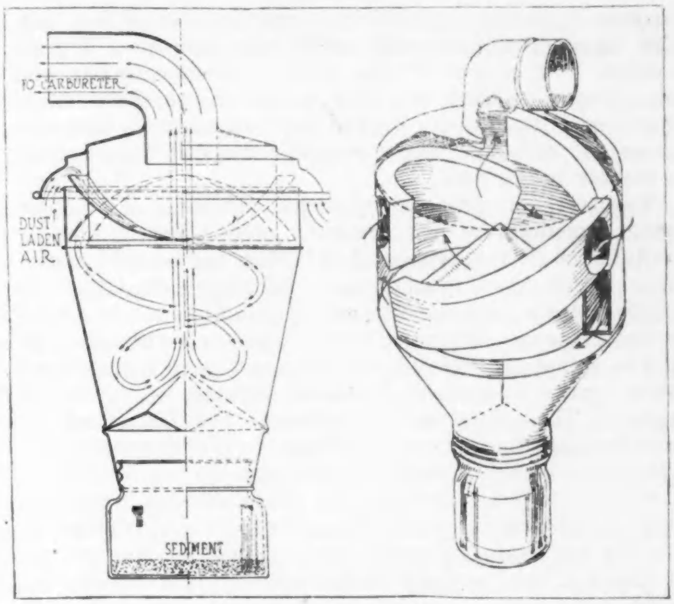


FIG. 6—WATER WHIRLING RAPIDLY THROUGH SPIRAL PASSAGES IN THE LOWER COMPARTMENT IS RELIED UPON TO CLEANSE THE AIR

This heavy moisture content which some air-washers impart causes a large water consumption, the amount varying with the temperature. One well-known air-washer is said to use up 30 quarts of water in a day's work, under ordinary summer temperatures. All air-washers are not as bad as that, but it is both troublesome and inconvenient to refill them twice a day. This fact and their susceptibility to freezing in cold weather form two of the main objections to an air-washer.

Figs. 5 and 6 are two forms of air-washer now in use. The first has an additional objection to those already mentioned, in that it employs a floating member with a large bearing surface exposed to the wearing action of the dust entering the cleaner. These surfaces are in the direct path of the dust, which must effect some wear if not actual clogging of the bearing.



FIGS. 7 AND 8—CENTRIFUGAL FORCE REMOVES THE DUST PARTICLES IN THESE TWO TYPES OF AIR CLEANER AND COLLECTS THEM IN A CONTAINER AT THE BOTTOM

Fig. 6 is a water cleaner brought out over a year ago to satisfy certain demands for a wet-type cleaner. It embodies several novel features designed to eliminate so far as possible some of the objectionable properties of the wet-type cleaner. It consists essentially of a centrifugal air-cleaner suspended within a cylindrical casing containing a quantity of water. This water is made to revolve within the container by the whirling action of the air drawn into it by the suction of the carbureter. The water rotates because the air is drawn into it tangentially through two spiral tubes in the inner circumference of the casing. The dust-laden air enters as shown and passes into the water compartment through openings in the spirals at *A*. The rapidly whirling air causes the whole mass of water to revolve so that it piles up against the sides in approximately the position shown by the dotted line. This completely submerges the lower ends of the spirals in a heavy spray, so that all the air must pass through the water spray before escaping upward into the openings *C* of the inner air cleaner.

The air-cleaner has three spirals on its inner circumference through which the air and entrained moisture pass. The centrifugal action set up in the inner cleaner breaks up any air bubbles, completes the cleaning of the air and also throws down any drops of water that may have been picked up in the air. These water drops are thrown downward and back into the water container through the open end of tube *B*. This reduces the humidity of the washed air and also prevents excessive water consumption. The clean air after passing out of the spirals in the inner cleaner escapes upward and out through the elbow at top to the carbureter air-intake.

As long as there is any water in the container, the whirling of this keeps the end of tube *B*, which is very close to the bottom of the container, sufficiently open for the thrown-down water to re-enter the reservoir. However, if the water supply is allowed to evaporate entirely, enough mud and dirt will settle under the open end of *B*

to seal it, so that even if the container should run dry, the inner air-cleaner will collect the dust as a dry-air cleaner. Of course, if the water container is dry and also clean, no such cleaning action is possible unless opening *B* is closed. Under normal summer temperatures one filling of water should last a full days' run of a tractor in the field.

The reservoir holds about 1 gal., which is a very low water consumption in comparison with others. The air contains so little moisture that it does not interfere with the carbureter action on gasoline, as is the case with some other water cleaners. The whirling action of the water in the reservoir creates a heavy spray over the openings of the spirals so that all the air must pass through the water spray instead of bubbling through a volume of water. This practically eliminates the formation of bubbles, thereby increasing efficiency. Furthermore, any particles of water containing dust are thrown out of the air while passing through the inner cleaner and drop back into the water reservoir again. This also accounts for the low water consumption. Except at the instant of starting, the frictional resistance of this water cleaner is no greater than that of an equivalent one of the dry type, because when once started it requires but little force to keep the body of water revolving.

Centrifugal-Type Cleaners

The fourth type of cleaner and the most widely used works on the centrifugal or gravity principle. Figs. 7 and 8 are examples of this type. Fig. 8 shows a centrifugal or gravity cleaner that is used on a large percentage of the makes of tractor which use air-cleaners. The air is drawn by suction through openings in the sides of the cleaner into the spiral tubes. These spiral tubes have a downward pitch which gives the dust-laden air a whirl, so that centrifugal action and gravity throw the dust out of the air under the cone and into the container below, while the clean air passes upward through the top and into the carbureter.

Fig. 8 is a centrifugal cleaner of the same type, differing only in outward appearance and size. The principle and action are identical and the construction nearly so.

There are several other forms of the four types of cleaner, but the ones shown and described are representative and serve to illustrate the principles and design involved.

THE DISCUSSION

A. W. Scarratt (M. S. A. E.):—Do you really think that the dirt thrown down in the cleaner will be solid enough to make an airtight seal?

Mr. Clark:—It becomes solid as the water evaporates.

Mr. Scarratt:—Will it be airtight?

Mr. Clark:—It will, if you get any considerable quantity of it. The bottom of the tube is about 1/16 in. from the bottom of the container, and if ¼ in. of dust collects there it becomes airtight. Of course, if the reservoir is clean and empty at the same time, you get no cleaning effect from the water, but if there is dust there and the water does evaporate, the farmer still has a cleaner.

R. B. Shoop (M. S. A. E.):—How much of a deposit will there be on the bottom at the end of a 10-hr. run when operating in heavily laden air?

Mr. Clark:—Judging from what the dry cleaners will catch under the worst conditions, about a pint in five hours. That is the worst I have ever had reported to me. I was out on an experimental job west of St. Louis a month or two ago where we had conditions as bad as I ever saw. We emptied the air cleaner and got approximately 1 in. of dust for every half-mile round.

A Member:—Do you have to stop the engine when you take the glass off to clean it?

Mr. Clark:—It is better to do so.

Effect of Dust on Engine

A Member:—Has any accurate test been made to determine what damage dust going through an engine of that kind causes?

Mr. Clark:—I have some pistons at the office which are sufficient evidence on that point. The rings at the top and the ring grooves are worn deepest at the top and the injury is less at the bottom of the piston. Some of the rings are cut into and worn bevel-edged. A representative of one of the prominent piston companies told us that this was impossible. We sent them the pistons to prove our point. If you have any doubt as to the destructiveness of dust take a tractor to the Western coast, or one of the Western States, like Idaho. There are some places in the West where a tractor cannot run for 2 hr. without clogging. Tractors have been known to quit cold on account of clogging up of the lubricating oil-holes, cutting out the bearings. There have been cases where the bearings were scooped out.

Chairman Mowry:—I have seen the pistons to which Mr. Clark referred. You could easily lay the lead of an ordinary pencil, after you had sharpened it in the usual way, in beside the piston under the upper piston ring. The next one was a little less worn; the third still less; the fourth one a little looser than it ought to be. The pistons had been run about four weeks.

Mr. Clark:—There was a thick deposit of dirt on the rings, which just about proves the case.

Decrease of Power

Mr. Haggerty:—What is the effect of the air cleaner on the power?

Mr. Clark:—In tests made on engines equipped with them, the loss of horsepower was so small we could not measure it. An engine developing 40 hp. would give a power loss of a little less than 1/40 hp. Of course, there is a slight restriction of the air. If the carbureter is adjusted to the change in air velocity, power loss cannot be detected.

Mr. Haggerty:—Is that true of the water cleaners?

Mr. Clark:—We have been able to detect very little difference between our water cleaners and the air cleaners. Very little power is required to keep the water revolving.

Mr. Haggerty:—I have heard several manufacturers protest against the amount of power lost with the water cleaners.

Mr. Clark:—I have not tested any of the makes other than ours as to friction.

Installation

Mr. Scarratt:—Are there any points regarding the installation of the air cleaner that it would be to our advantage to know?

Mr. Clark:—The object in installing an air cleaner is to get one with the greatest efficiency and the fewest drawbacks. One of the drawbacks is loss of power. The farther the cleaner is placed away from the carbureter the more power is lost, no matter what system is used. Flexible steel tubing is one of the best means of clogging a cleaner. It figures about 1 hp. lost for every 4 ft.

If the carbureter and air cleaner must be connected with steel tubing, the closer they are the better and the straighter the tube the better. The cleaner should be supported from its body, not hung from the top. Most cleaners are made of sheet metal because of its light weight. Hang the cleaner on the engine and not the engine on the cleaner.

MR. SCARRATT:—Have you made any tests on the flexible metal tubing to determine how nearly airtight it is?

MR. CLARK:—No. I have been assured by makers that with packing in the joints it is airtight.

MR. DONALDSON:—I have heard that an air cleaner should not be placed in front of the breather or opposite the flywheel because the oily vapor it gets will mix with the dust and clog it.

MR. CLARK:—That is true.

A MEMBER:—Mr. Clark has stated that in very hot weather the water cleaner tends to cool the engine. When some water cleaners are used in cold weather the engine cools too much and after a while it will not run at all, so I think the combined air and water cleaner is an improvement over the water type because even with the water let out there is still a cleaner. Otherwise it would be necessary to disconnect the carbureter from the cleaner.

G. C. ANDREWS (M. S. A. E.):—We used to make a number of oil separators to take oil out of steam. Why not use the principle of these to keep dust out of tractor engines?

MR. CLARK:—That could be done, but the volume or area you would have to use would be too great. The cleaner would no longer be an accessory.

CHAIRMAN MOWRY:—That is one of the chief points. The air cleaner must be small enough to fit in close to the engine and not be in the way of anything else. On one tractor the air cleaner is installed in such a way that to run on the belt the cleaner must come off.

MR. SCARRATT:—And that is when it is needed most.

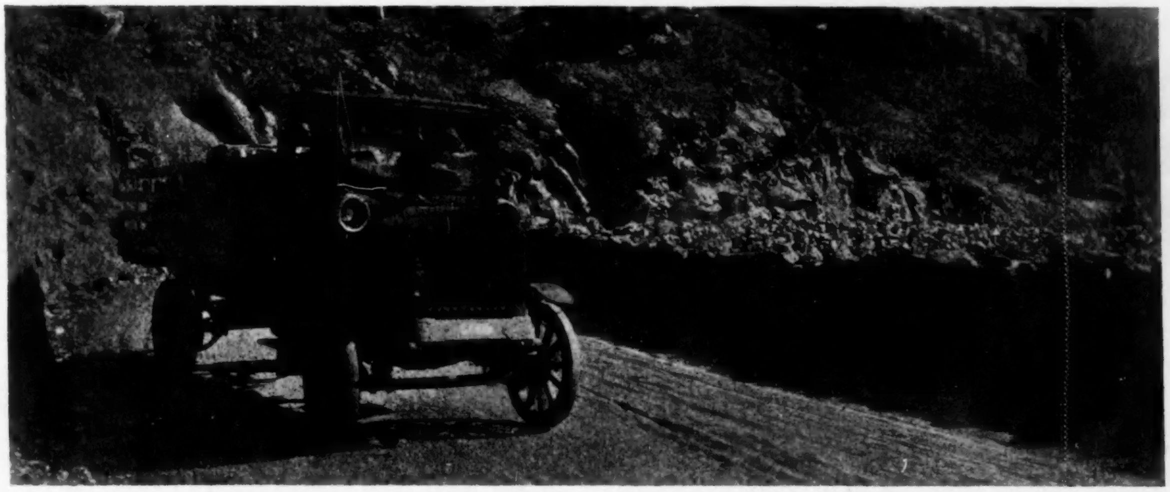
A MEMBER:—How fast does the water revolve?

CHAIRMAN MOWRY:—How near does it attain the velocity of the incoming air?

MR. CLARK:—That would be rather hard to measure. We do not aim at an air velocity greater than 4500 ft. per min. Whether the water attains that speed I do not know.

HIGHWAY TRANSPORT EFFICIENCY

ACCORDING to W. K. Brown, chief of the efficiency division, Colorado Highways Transport Committee, motor transport efficiency is obtained by using as many motor trucks as possible to cover a given territory, obtaining for them sufficient tonnage both ways to make it profitable to the transport owner and advantageous to the shipper. The chief obstacle encountered in Colorado was in getting men or corporations of sufficient means to operate the various lines, and to weed out from those who are now operating the ones which have insufficient capital. This is accomplished by requiring all persons or corporations now operating or expecting to operate to file with the Committee a financial statement with the names of references. Blanks are sent to these the same as a bonding company. When these references are returned with the financial statement they are examined and if in the minds of the Committee the applicant is financially responsible, a permit to operate is then mailed to him. This permit is revocable for failure to give proper service to the shipper.



MOTOR TRUCK IN UTE PASS; A TYPICAL EXAMPLE OF THE ROADS TRAVERSED BY A MOTOR EXPRESS IN COLORADO

The method of handling the motor transport companies or owners will be to go before the State legislature and have a bill passed that will make all motor truck owners operating rural motor express or motor transportation common carriers. This would place them under the jurisdiction of the Public Utilities Commission which would compel them to register and to comply with such regulations as might be already in force regarding common carriers.

Also law will be asked for requiring the owners of motor transport trucks and rural motor express trucks to file with the Secretary of State or the Highway Transport Committee a financial statement and an indemnifying bond for each truck or trailer, in use for transportation. The amount of the bond is to be decided by the carrying capacity of the truck or trailer and to obtain this bond the owner should be investigated as to his responsibility by the bonding company.

The third method is by a blanket insurance policy protecting the shipper against loss or damage to any merchandise while in possession of the motor truck owner. This policy should be made out to one of the departments which would be authorized by law to handle these claims and the shipper would file his claim with the department handling this work and it in turn would file the claim with the insurance company, and upon settlement of a claim would turn it over to the shipper.

Fixed Radial Cylinder Engines

By JOHN W. SMITH* (*Member*)

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS

THIS article will treat chiefly of fundamental characteristics, the sum of which is a measure of the real value of an airplane engine. Detail comparison will not be attempted.

With the experience gained from the war, we find Great Britain keenly interested in the fixed radial cylinder, air-cooled engine. She has taken the lead in the development of this type, has spared no expense, and has demonstrated its merits for aviation to her own satisfaction. It is, I believe, only a question of time before this engine will be sufficiently well known to cause America to turn her attention to it.

The V-type water-cooled engine has been fully developed and the Liberty engine represents, perhaps, the last word in the development of this type. It is my belief that the future has little in store that will greatly improve it. The V-engine was developed largely by the automobile industry and is in effect, and quite naturally, built largely along automobile lines. It is, however, as we shall see, lacking in certain desirable characteristics which if they can be realized mean a much improved airplane powerplant.

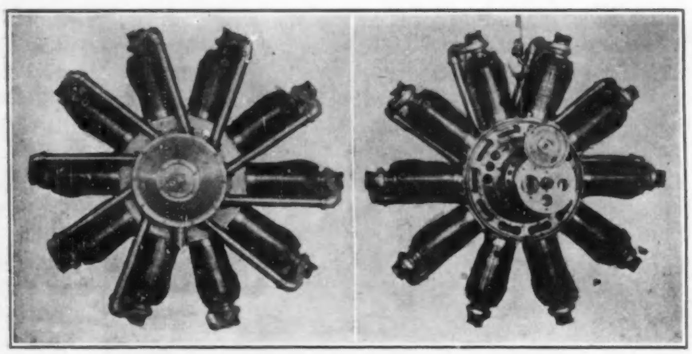


FIG. 1—FRONT AND REAR VIEWS OF TEN-CYLINDER 200-HP. SMITH-FIXED RADIAL ENGINE

The revolving air-cooled engine, like the V-type water-cooled type, has been fully developed, and most if not all of its possibilities have been realized, while its disadvantages are well understood. At present the United States and Great Britain are both ready to discontinue the use of the rotating air-cooled engine because of certain inherent disadvantages, therefore, neither this type nor the radial water-cooled, will be discussed at length. It is my belief that while the radial water-cooled engine may, when properly developed, be an improvement over the V-type water-cooled unit, it will still be much heavier than the radial air-cooled type.

At the present time there are two distinct designs of fixed radial air-cooled engine. Both have been tried out by the British Government and have seen some service.

I was in England the first two years of the present war, conducting experiments for the British Government on a fixed radial air-cooled engine. From the information gained as a result of my own experiments, together with the development work of others, I am convinced that the fixed radial air-cooled engine will excel in each of the following fundamentals:

(a) Weight of powerplant per horsepower, the fuselage mounting and space required being duly considered
(b) Reliability and durability
(c) Fuel and oil consumed per horsepower-hour
(d) Streamline mounting, with armor, if desired
(e) Quick detachability of powerplant, and accessibility
(f) Freedom from certain inherent difficulties peculiar to water-cooled engines

WEIGHT OF POWERPLANT

There is a great deal of confusion about comparing weights of engines. It is customary to refer to the weight of the water-cooled engine by giving the weight dry, which omits the weight of the water and radiator. A fair comparison of weight should include the entire powerplant mounted in the fuselage with sufficient fuel and oil for some hours of operation. The water-cooled engine requires more fuselage space and in addition elaborate sheet-metal casing and exhaust piping to complete the powerplant. The mounting of a nine or ten-cylinder radial air-cooled engine shows a saving in weight over the water-cooled, when all elements are included. If the entire powerplant is included in giving the weight of the water-cooled engine, it will be found that the lightest water-cooled type, which is probably the Liberty engine, will weigh over 2.7 lb. per hp. for the 400-hp. size as installed in the airplane. Smaller water-cooled engines will weigh 3½ lb. or more per hp. The English Rolls-Royce 300-hp. engine weighs 3½ lb. per hp.; weights made up as follows: Engine 860 lb., radiator and water 167 lb., exhaust pipes 33 lb.; a total of 1050 lb., or 3½ lb. per hp.

Fig. 1 shows a 200-hp., ten-cylinder radial air-cooled engine of 4 17/32-in. bore and 6¼-in. stroke, which weighs less than 1.8 lb. per b.hp., installed. A 400-hp. ten-cylinder engine, which is illustrated in Fig. 2, has 5½-in. bore and 6½-in. stroke, and an estimated weight of 1.3 lb. per b.hp. The nine-cylinder engine, Fig. 3, has 5½-in. bore and 6½-in. stroke, and is said to develop 310 hp. and weigh 640 lb., or 2.06 lb. per b.hp.

It will thus be seen that the fixed radial-type engine has a weight advantage of fully 0.6 lb. per hp. over the water-cooled type, and it can be designed to have a much greater advantage.

RELIABILITY, DURABILITY AND BALANCING

The construction of the fixed radial engine makes for reliability, because of simplicity and compact design. The English have developed the roller bearing to a point where it is practically infallible for crankshaft and connecting-rod applications. This is applied to the nine-cylinder engine, as well as to the engine shown in Fig. 3. A simple oiling system is adaptable to an all-roller

*Designer of fixed radial airplane engines, Philadelphia.

bearing, fixed radial engine. The ten-cylinder engine shown in Fig. 2 has an oiling system that does not depend upon a fixed pressure and in which the oil is sprayed from one point only. The circulating and fresh supply of oil is pumped through the hollow crankshaft and is thrown off by centrifugal force onto all the cylinders in a uniform manner, the bottom cylinder getting the same supply as those at the top. This oiling system works out well in practice.

The connecting-rod layout used on the same ten-cylinder radial engine is extremely simple and has proved to be one of the most reliable arrangements ever used on any type of engine. An engine equipped with the same rod design was flown over 8000 miles on a British military airplane which is equivalent to running the engine for over 100 hr. without any adjustment of the rods. Engineers who examined the rods and bearings estimated that at least 400 hr. service might be expected. The connecting-rod design used in the nine-cylinder engine, Fig. 3, has been used extensively in the revolving-cylinder type engine, and was found to be satisfactory, but is limited to the single-throw crank, which does not give the mechanical balance found in the ten-cylinder engine shown in Fig. 2. To produce a perfectly balanced fixed radial engine, the axes of all cylinders should be in the same plane, and the pistons connected to opposed two-throw cranks.

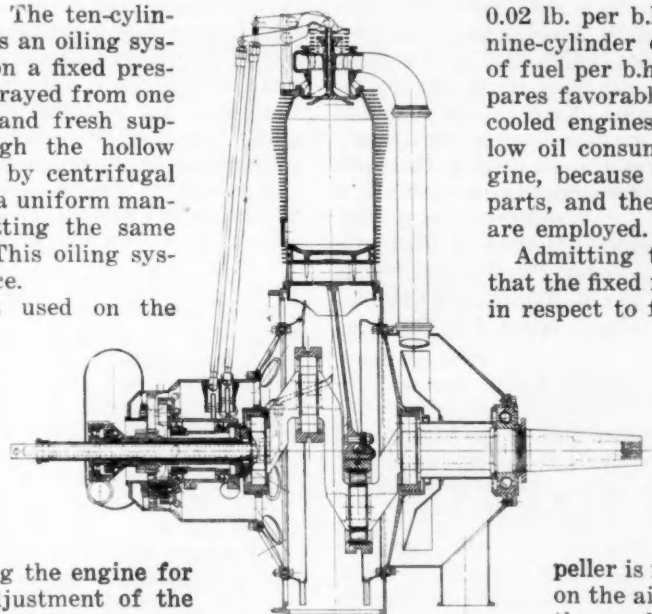


Fig. 2—Lateral Section of 400-Hp. Smith Fixed Radial Engine

In this connection it is worth noting that the nine-cylinder engine, with single-throw crank, must be counterbalanced by weights, as shown in Fig. 3. For this reason it is evident that considerable weight can be saved by resorting to the double-throw crank construction shown in Fig. 2.

The foregoing are factors affecting reliability and durability which cannot be said to apply, at least in the same degree, to other types, when due regard is given to light construction.

Fuel and Oil Consumption

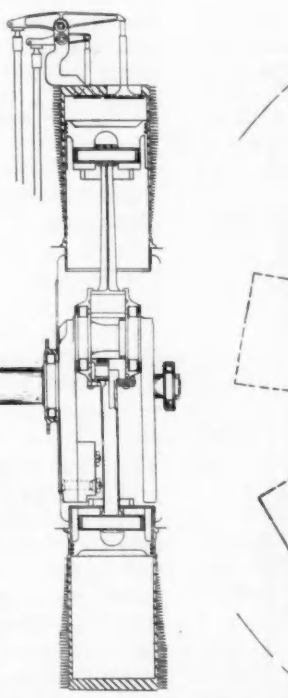
There is every reason to believe that the fuel consumption of the fixed radial engine should be at least as good as that of the conventional V-engine, since the mean effective pressure at high speeds can, with proper design admitting of adequate valve and piston cooling in combination with reasonably high compression, be made to equal that in the best water-cooled practice, while bearing friction is less with roller-type bearings than with plain bearings.

Official British reports on the ten-cylinder engine, Fig. 2, have credited it with a fuel consumption of less than 0.50 lb. per b.hp.-hr., and oil consumption of less than 0.02 lb. per b.hp.-hr. I understand that the nine-cylinder engine uses less than 0.45 lb. of fuel per b.hp.-hr. This consumption compares favorably with that of the best water-cooled engines. There is no question about low oil consumption for the fixed radial engine, because of the compact disposition of parts, and the fact that only roller-bearings are employed.

Admitting these facts, it is readily seen that the fixed radial type of engine does excel in respect to fuel and oil economy.

Streamline Mounting

In the course of considerable development work on both wood and steel propellers, with the object of increasing their efficiency, I have found that near its center the work done by the propeller is negative; that is, the work done on the air in this region is greater than the work resulting in thrust. This is due largely to the relatively poor aerofoil section required for structural reasons. The difference of pressure of the air before and after it is acted upon by the propeller causes an eddy near the center of the propeller, and this tends to increase the negative work further. It is, therefore, important to prevent circulation of this air near the center, and this can be done by a proper propeller cap, as illustrated in Fig. 4 for fuselage mounting, or Fig. 5 for wing mounting. In the case of a well-designed propeller now being extensively used, the thrust resulting from that part of the propeller with a 20-in. radius was found



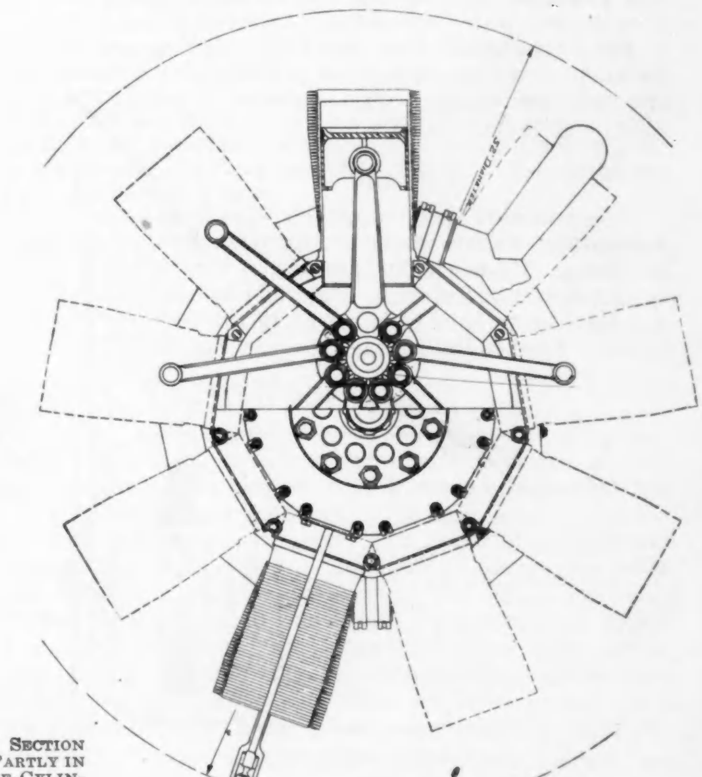


Fig. 3—Lateral Section and Elevation Partly in Section of Nine-Cylinder Engine of British Manufacture with Some Details Omitted

to be less than 5 per cent of the total available at the normal speed, while the negative work done by the same part is such as to result in a net loss, which can be decreased by a proper cooling forward and back of the propeller. Within this space a radial engine can easily be mounted in such a way as to result in no loss, and probably in a net gain in reduced parasitic resistance. Hence the radial-type engine does not suffer by comparison with other types in this respect. In fact, the water-cooled powerplant, with radiator and fuel tank, cannot be as efficiently streamlined as can the ten-cylinder fixed radial type. Fig. 5 shows wing mounting for a 400-hp. ten-cylinder fixed radial powerplant with ample space for fuel and oil tank.

Mounting Advantages

It is very interesting to compare the V-type engine and the fixed radial engine, both mounted in the fuselage. The water-cooled engine shows an extremely complicated mounting in comparison with the fixed radial. The water-cooled engine may be termed the fore-and-aft type, and the fuselage is practically built around the engine, of which it virtually becomes a part. This results in relative inaccessibility. Fig. 4 shows the fixed radial engine properly installed in a streamline mounting. By removing two bolts the front portion of the casing can be removed, exposing the engine for inspection. Any necessary adjustments can readily be made, and cylinders and pistons easily removed and valves ground, without interfering with the installation as a whole. The entire powerplant can be removed, if desired, by releasing four bolts and disconnecting the fuel and oil pipes, there being no troublesome water connections to interfere.

The steel shell in which the engine is mounted can also be made of armor-plate, thus protecting it without adding excessive weight. These surely are points of superiority not to be overlooked.

Cooling

It is admitted that the cooling of a fixed radial-type engine presents some serious problems. These are, however, by no means insurmountable, and most, if not all of them, are believed to have been solved in the ten-cylinder fixed radial engine shown in Fig. 2,

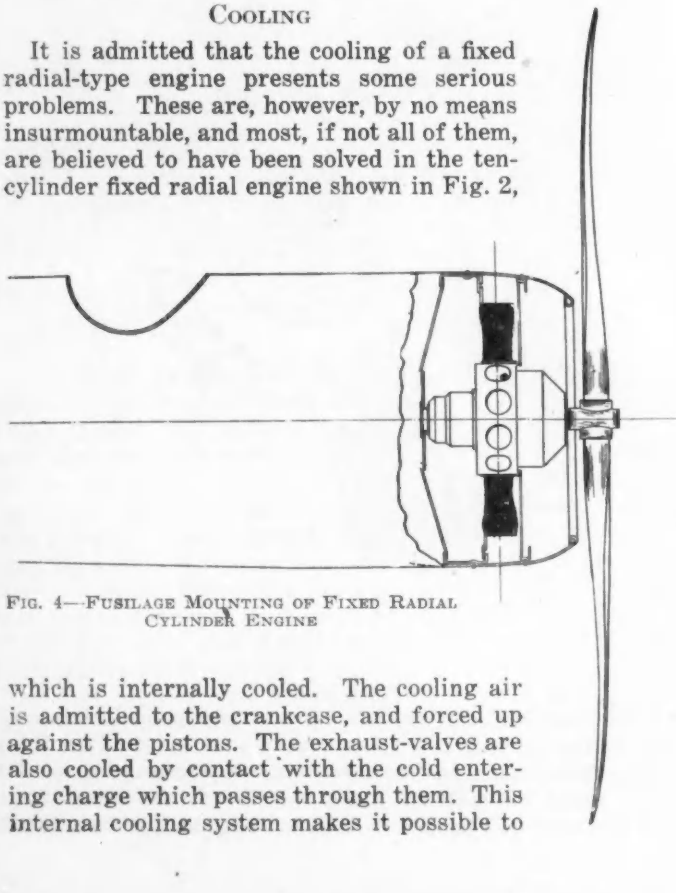


Fig. 4—Fusilage Mounting of Fixed Radial Cylinder Engine

which is internally cooled. The cooling air is admitted to the crankcase, and forced up against the pistons. The exhaust-valves are also cooled by contact with the cold entering charge which passes through them. This internal cooling system makes it possible to mount the engine in an enclosed steel shell which is simply a continuation of the fuselage. The nine-cylinder engine referred to has no facilities for internal cooling. It is, therefore, not installed inside a streamline shell. To cool the nine-cylinder engine properly at least one-third of the cylinders are placed in the slip-stream of the propeller. This necessitates small exhaust pipes to prevent hot oil from reaching the pilot.

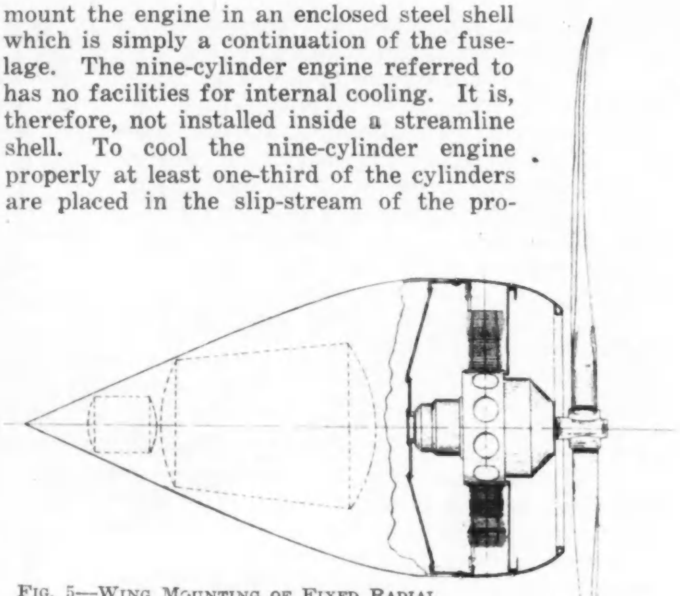


Fig. 5—Wing Mounting of Fixed Radial Cylinder Engine

The disadvantages of a water-cooled powerplant for both military and non-military uses are so obvious that it is not necessary to compare in detail the advantages of the fixed radial air-cooled type, further than to suggest that it is easier to control the cooling air on the ten-cylinder powerplant shown in Fig. 2 than it is to prevent the water from freezing in the case of a water-cooled powerplant, and to point out that it is easier to provide a supply of cooling air to an air-cooled design than it is to maintain a non-leaking water system.

Conclusion

If, then, the fixed radial air-cooled powerplant for aeronautic use possesses so many advantages, it is natural to inquire why it has not seen wider application. The reason for this is quite obvious to those who are familiar with conditions that have existed during the war. The water-cooled V-type engine was a known factor. While the perfection of a water-cooled engine suitable for quantity production presented many problems, as those who were instrumental in developing the Liberty engine will readily admit, it was quite properly felt that these were easier and more certain of rapid and definite solution than were the problems involved in the fixed radial air-cooled type. These circumstances, and the fact that this country was faced with a serious military problem which required prompt and certain solution, made it most advisable to follow the course which was adopted. However, now that the war is over, and there is more time for normal development, is it not fair to assume that an engine possessing the inherent advantages pointed out in this paper will be perfected and see wide use? It is my belief that this question will be answered in the affirmative.

More than fifty different woods are known as mahogany. This fact causes confusion, and the Forest Service, of the U. S. Department of Agriculture, has been asked to identify and classify the various mahoganies, so that the trade will have a definite guide in making specifications.

AMERICAN MORALE

"'LET us establish first," said Foch, "that in order to duly fulfill the double purpose of being the logical aim of strategic operations and the effective means of tactics, battle cannot be merely defensive.

"Under that form it may, it is true, halt the enemy in his advance; it keeps him from attaining some immediate objective; but such results are purely negative. Never will it destroy the enemy or procure the conquest of the ground he occupies, which is the visible sign of victory. It is unable, therefore, to ever create victory.

"This is an elementary principle, if you wish, but neglect of it has been frequent. It was not understood by the French Armies of 1870 or they would not have pictured as victories days like Aug. 14 or 16, 1870, and many others, which might have become victories but which certainly were not victories at the stage where they were left. The French had merely held their positions, which is not synonymous with victory, and even implies future defeat if no further offensive action be undertaken.

"'To make war was always to attack.' (Frederick)

"We must always seek to create events, not merely to suffer them. We must first of all organize the attack, considering everything else of secondary importance and to be planned only in respect to the advantages which may result from it for the attack."

The last great German drive toward the Marne and Paris was begun at midnight on July 14, had collapsed at noon on July 15 and was abandoned on July 16. Foch, with the American Army reinforcing his old forces and serving as a reservoir for practically unlimited reserves, was ready to strike.

On July 17, without the knowledge of the enemy, Foch concentrated in the Forest of Villers-Cotteret an army of assault, including two American divisions.

His preparations were amazingly rapid and efficient. The attack was launched at daybreak on July 18, right smack up against the German lines. The greatest advance was laid out for the two American divisions and the Moroccan division of the French Army.

Behind a terrific barrage and an army of tanks the American-French troops swarmed into the German positions and caught the enemy asleep. The movement was carried through rapidly. At noon on July 18, the advance had penetrated a distance of 6 miles and the German forces in that sector —namely, below Soissons—were in rout.

The right flank of the German Army in the Chateau-Thierry sector was turned, and the center and left flank in the salient were compelled to retire. Foch struck at them as they were moving out, using, among other American forces, the Forty-Second Division which had been rapidly moved down from the Plains of Chalons. The vigor, the daring, the resourcefulness of the eager young American troops were wonder-compelling.

An improvement in morale ran along the Marne battle line from the Marne to the North Sea like a thrill. Foch struck at Soissons with French troops and the Germans gave way. He struck with the British in Flanders and the Germans gave way. He struck with Pershing in Lorraine and the Germans gave way. He struck when and where he pleased with massed forces, always supported by sufficient reserves, and always the Germans gave way.

Leavened by the fresh morale of the American troops the British, French and Belgians were unconquerable and are unconquerable. New York's National Guard Division and the "Wildcat" Division from the South fought side by side with British and Belgians and inspired them with American determination.

An illuminating passage from one of Foch's lectures can be used in connection with one phase of the activities of our troops in the July offensive. Foch said:

"When the time comes to act artillery shakes the enemy's resistance and infantry must destroy it. To compel the enemy's retreat one must march on him; to conquer the position, to take his place, one must go there. The most powerful of fires does not give that result and here begins the work of the masses of infantry. They march straight to the objective, increasing their speed as they draw nearer, preceded by violent fire, in order to assault the enemy bodily and close the argument with cold steel by greater courage and determination."

Our young soldiers had never read Foch's book; few of our young officers had read it. But when they were called on to attack they marched on the enemy. When their objective was a certain place they went to that place. They marched into machine gun fire and overcame machine gunners with cold steel and their bare hands. They closed the argument by bodily assault.

And Foch had known they would before they started.

On Nov. 1, twenty-one American divisions were engaged.

—Martin Green, *in N. Y. Evening World*

AMERICAN AUTOMOBILES IN THE FAR EAST

ROAD construction is the limiting factor in the future market for motor vehicles in China. As a general rule there are no roads suitable for motor cars outside the foreign concessions of treaty ports, although there are some 150 miles of street in Peking and a few short stretches of good road here and there throughout the Republic. There is at present some agitation for better roads and a realization on the part of both Chinese officials and foreign residents that highways are essential to the development of the vast resources of that country.

Japan has only 2700 cars in all makes, although here, as in China, American cars predominate. There is money in the buying class and a strong desire to own cars, but here, also, lack of suitable roads and bridges has tended to keep the sales down. The only recent improvements have come about largely as a result of military requirements. Undoubtedly, Japan will eventually build her own cars, but progress thus far has been slow. Hawaii has purchased more motor vehicles than China and Japan combined and the market there is attractive even though limited. The great sugar companies have found it economical to haul their workmen to and from the plantations in motor trucks, and this has made the unfamiliar mode of locomotion popular.

The Diesel Engine*

By Herbert Haas (*Non-Member*)

THE reliability of the fuel pump and its sensitiveness in responding to the slightest variations in load largely determine the satisfactory operation of the Diesel engine. The pump must respond to the governor instantly and must furnish a supply of fuel accurately proportioned to the needs of the engine load. The permissible variations have to deal with extremely small volumes of fuel.

We may distinguish between pumps that do not have to force the fuel against the high pressure of the injection air but supply the fuel to open nozzles, and pumps that must deliver the oil against the injection air in closed-nozzle valves.

Pumps of the first type have to work against little resistance—merely that due to pipe friction and the low lift from pump to fuel valve; the oil supply can therefore be regulated with close accuracy by varying the stroke of the pump plunger, which is under governor control.

Pumps of this type are simple, work well, and are subject to little wear. When they are working under low pressure, the stuffing boxes are easily kept tight and give no trouble. They respond readily to the governor, and accurately adjust themselves to the smallest load variations.

In a fuel pump, driven by an eccentric on the lay shaft, the plunger is of the differential type, the upper or larger part being hollow and having seated at its upper end a cut-off valve. The plunger has a full positive stroke with each revolution of the lay shaft. The cut-off valve is under direct control of a Jahns governor. Governing is effected by permitting the cut-off valve to seat at a predetermined point in the upstroke of the plunger, thus delivering to the fuel valve a quantity of oil, correctly proportioned to the load that the engine is carrying.

Pumps Designed to Force Fuel Against High Pressure

Pumps of the other type have to be designed to withstand safely the maximum pressure against which they have to deliver the oil, namely 1000 lb. per sq. in. They have to force the oil into the fuel-valve chamber, which is under the pressure of the injection air that varies from 600 to 1000 lb. per sq. in. Pumps of this type have to deal with extremely dense and correspondingly sluggish liquids.

For this reason no attempt is made, in pumps of this class, to place the pump plunger under governor control and to regulate the fuel-oil supply by varying the stroke of the pump plunger in proportion to the fuel required by the engine. The high pressure under which the plunger has to work would react on the governor with each stroke, affecting its precision unfavorably and demanding a more powerful governor. There is also the possibility that air may be drawn into the plunger barrel during the suction stroke; with the minute quantities of oil to be delivered to the engine, especially at partial loads, a small air bubble may displace all the oil, and as air is an elastic medium, may be compressed and expanded and seriously interfere with the functioning of the governor.

To avoid these difficulties the pump plunger works with a constant stroke, furnishing a supply of oil exceeding the maximum quantity required by the engine when working at full load. The excess fuel is by-passed, the suction valve being held open, the degree of opening being in inverse proportion to the load of the engine. The pump plunger thus delivers only the exact quantity of fuel required by the engine load. The suction valve is under governor control and is actuated through a push-rod with constant or variable stroke.

In some pumps the push-rod has a constant stroke, but the starting point of its travel is influenced by the governor, and it subjects the lift of the suction valve to the same variation in travel. Pumps of this type are usually provided with a hand-crank which permits the lifting of the suction valve to its extreme position and the lifting of the discharge valve sufficiently off its seat to let the oil flow by gravity into the pump chamber and the fuel-valve oil-delivery pipe from the oil-storage tank (which is higher than the engine) by opening a cock connecting the pump chamber with the atmosphere. When the suction valve is held wide open the engine is stopped. These pumps have been developed to a high degree of perfection, and notwithstanding the severe conditions under which they have to operate they are highly reliable.

Pumps may be vertical or horizontal; the former are used if operated from the camshaft, although pumps with a variable stroke of the plunger are usually of the horizontal type. Pumps driven from the vertical governor shaft of the vertical engines are usually horizontal.

Number of Pumps Required

Practice regarding the number of fuel pumps supplied with multi-cylinder engines differs, being often decided by a desire to reduce manufacturing costs.

When only one pump is supplied the fuel has to be divided and proportioned equally to the different cylinders. This is done with small steel diaphragms, the size of the holes being determined experimentally, allowance having to be made for the resistance in the different pipe branches leading to each fuel valve. This method is not entirely satisfactory, especially where a high degree of regulation is desired, as in synchronizing. With a decrease in load, some of the cylinders will receive an excess of fuel, the supply being proportioned to the load before the governor acted. If one or more of the branches is obstructed the active cylinder will be overloaded, and if any of the fuel valves or the fuel passages to them leak the active cylinders will be underloaded.

In pumps that are driven by the vertical governor shaft, which in an engine having a four-stroke cycle makes double the number of revolutions of the camshaft, the plunger delivers the fuel in two parts for any one fuel charge, corresponding to one revolution of the camshaft. The governor, by acting between the two plunger strokes, can therefore adjust the second part of the fuel charge to the new engine load, counteracting somewhat the defect mentioned. As a result of the desire to improve the regulation further, individual pumps are often built as multiplunger pumps, one plunger being provided for each fuel valve (each cylinder). As the

*U. S. Bureau of Mines Bulletin 156, Part II (condensed).

plungers are driven simultaneously by one eccentric device they divide the fuel effectively, but the governor continues to influence only the combined quantity of fuel delivered by all the plungers and not of that delivered by each plunger successively.

To avoid these defects many builders provide an independent pump for each cylinder, each pump being separately under the influence of the governor. The cams or eccentrics actuating these pumps are mounted on the camshaft (or the governor shaft) with different leading angles, corresponding to the sequence at which the different fuel valves act, and each pump delivers the oil just before the fuel valve it serves opens. Engines so equipped have the most effective regulation.

Air Compressors and Receivers

The air required for starting the engine and for atomizing and injecting the fuel is furnished by an air compressor. On account of the high pressure necessary, the air is compressed in two or three stages. Ample cooling of the compressor cylinders and of the air in intercoolers between stages is not merely desirable to approach isothermal compression and reduce the power needed for compression, but is necessary to avoid accidents that may wreck the compressor, with possible injury to the operators. With insufficient cooling of air and excessive use of cylinder-lubricating oil or of an unstable oil, the oil vapor may form an explosive mixture with the heated air and be ignited upon compression. Three-stage compression is therefore much to be preferred, as it permits compressing the air more gradually, and the lower compression ratios avoid excessive terminal temperatures; it also permits cooling the air more thoroughly in intercoolers before it is passed from one stage to the succeeding stage.

The air leaving the last stage of the compressor should be passed through an aftercooler and an oil separator before it is stored in the air receivers. This step is taken not so much to prevent a drop in pressure in the injection air bottle, with the contraction of the heated air on cooling, as to avoid explosions of the heated air charged with oil vapor. Regrettable accidents have happened from failure to provide intercoolers and aftercoolers. Not only pipes, but air receivers as well, have burst. Flame passing through the air pipe and into the air receiver charged with oil vapor has ignited this vapor and blown up the receiver. The aftercooler cools the air, and the oil-and-water vapors are condensed in the separator and from time to time are drained.

The air compressor should be lubricated thoroughly, but without the use of an excessive quantity of oil. The oil used should have a paraffin base, should be of great stability at high temperature, and should have high flash and burning points.

The air compressor is usually driven direct from the main shaft of the engine. On multicylinder engines with closed crankcase the compressor usually has the appearance of an additional cylinder, the compressor cylinders and pipe-coil air coolers being surrounded with a mantle forming a water space.

On some engines, especially large units, more than one compressor is used to avoid the large size necessary with only a single compressor. Moreover, greater accessibility and reliability are obtained, and the work of compression is divided into a larger number of smaller absolute impulses.

Compressors may be vertical, horizontal, or inclined for both vertical and horizontal engines. They are made of cast iron, with water-jacketed cylinders, or are surrounded by a mantle which forms a large water space and in which are housed the air-cooling coils. More systematic cooling can be done by using water-jacketed cylinders and independent intercoolers. Also, these then become more accessible. The cylinders are stepped down to correspond with the number of stages; likewise the pistons, which are of cast iron. The high-pressure end is usually too small in diameter to permit extending the snap rings sufficiently to slip them over the piston. They are then held between spacing rings and locked with a nut in the end of the piston.

The valves are metal poppet or disk valves. The discharge and intake valves between stages are preferably housed together in one cage, of a construction that facilitates their removal and replacement. The high pressure demands small clearance spaces; the interior of the cylinder-head end should therefore be free of pockets or dead spaces, and the valve-seats should conform closely to the inner surface of the cylinder; the piston likewise should conform to the shape of the cylinder head to permit its close approach to the head. Each intercooler should be fitted with an oil separator, so that excess lubricating oil and condensed water can be separated and drained and not allowed to pass on to the next stage.

A blow-off (safety) valve should be placed in the high-pressure air pipe leading to the air receiver, directly back of the high-pressure end of the compressor (past its discharge valve), to prevent the bursting of the pipe as the result of an obstruction. The necessity of an aftercooler and an oil separator has already been mentioned.

Compressor troubles are probably responsible for a large proportion of shutdowns in the operation of the Diesel engine. Particular care should be used in compressor construction to make all the parts as simple as possible and still retain the maximum efficiency and reliability. Valves should be readily interchangeable, and the material and workmanship of the highest order.

The air for the compressor is usually stored in three air receivers, two large ones for the air used in starting the engine and a smaller one for the injection of air. These receivers are made of seamless drawn steel, and to avoid heavy walls and excessive weight are relatively long and of small diameter ($L/D = 4$ to 8). They are interconnected with a system of pipes controlled by valves, so that either of the large bottles can be replenished with air from the injection-air bottle, which is supplied from the air compressor. The valve bodies are machined out of solid forged-steel blocks. The valve bodies are connected to the air pipes by copper cones and steel gland nuts. The valves are controlled by large (8-in.) hand wheels.

One of the large air bottles is used for storing a reserve supply of air under a pressure of 1000 lb. per sq. in. Air is drawn from the other when the engine is started. The latter bottle is refilled as soon as the engine is in operation. The air compressor is designed amply to replenish in 15 to 20 minutes' running the air so used without drawing on that used for injecting the fuel with the engine at full load. Manometers are provided to indicate the pressure in the large bottles and the injection-air bottle and the intermediate pressure of the compressor. At least one of the large air receivers is filled with air at the manufacturer's works and shipped with the engine to be used in starting it for the first time. Before the engine is started at any time the operator should convince himself that every part of it

is in operating condition; should he fail to start it by turning on the starting air he should close the air valve at once and locate the cause of failure rather than make a number of attempts and waste the compressed air.

If all the air has been used before the operator has succeeded in starting the engine which operates the compressor for producing a fresh supply, compressed carbon dioxide (carbonic-acid gas) can be used in lieu of compressed air. To prevent the freezing of the gas when it is drawn, the top part of the container may be warmed by wrapping cloths soaked in hot water around it. The container should not be heated by such means as torches, as there is great danger of bursting it from overheating the gas.

The size and the number of air receivers vary with the size of the installation. In powerplants using a number of engines it is well to interconnect the air receivers of the different engines, so that any one can be drawn upon in emergencies for any of the engines. Small engines need a relatively greater air-storage capacity per horsepower than do large engines. The capacity required varies from 15 to 20 gal. per 100 hp. for the injection-air bottle and from 60 to 200 gal. per 100 hp. for the starting-air receivers.

Regulation of Air Supply

The air supply to the fuel valves is regulated by throttling the discharge valve on the injection-air bottle, and the desired pressure, indicated by a manometer on the injection-air bottle, is maintained by correspondingly throttling the air going to the air compressor at the air intake.

Each bottle is provided with a cock and a drain-pipe reaching to the bottom of the bottle to drain it of accumulated condensed water and oil.

For starting some engines, low-pressure air is used (100 to 250 lb. per sq. in.), which is stored in the standard type of sheet-steel, riveted air receivers. The receivers are filled with air drawn from the injection-air bottle and supplied by the air compressor. In other engines the air receivers are eliminated altogether and a seamless steel pipe is used between the compressor and the fuel valves, the pipe taking the place of the injection-air bottle. A separate small compressor, driven by a gasoline engine, supplies the starting air. This practice lowers the first cost of the engine, but the absence of any air reserve makes it necessary that the compressor furnishing the injection air be of unfailing reliability. With the opening and closing of the fuel valves and the lack of sufficient receiver capacity the pressure fluctuates, and with an obstruction in the pipe the pressure may rise abruptly and burst the pipe, as even the precautionary blow-off valves cannot be depended upon to act unfailingly. The presence of a gasoline engine with its highly inflammable fuel introduces a fire risk that is absent in installations that derive the starting air from the engine-driven compressor and have in the engine room only a small supply of fuel oil with a high flash point. This advantage of the Diesel engine should not be appraised too lightly in many industrial plants, such as textile and flour mills.

As the volume of air drawn into the engine is considerable—about 635 cu. ft. per min. for a 100-hp. engine having a four-stroke cycle and about 850 cu. ft. per min. for an engine having a two-stroke cycle—especially in large installations, means of admitting an excess of air to the engine room must be provided. However, the noise will probably be considerable and the windows will vibrate and shake under the continuous waves produced by the periodic air displacements. It is therefore a better plan in large installations to draw the air from the outside through large conduits built in the foundation and connecting with the different air intakes to the valves.

Two-stroke engines are provided with air through the air (scavenging) pump, so it is necessary merely to have the pump intake connected with the air canal.

Wherever the air is likely to be contaminated with dust, it should be filtered to prevent excessive cylinder wear and the shortening of the life of the engine.

Exhaust Pipes

The exhaust pipes should be of cast iron, as steel pipes corrode rapidly, especially when the fuel oil contains an appreciable quantity of sulphur. The sulphur burns to sulphur dioxide, which may be oxidized to the trioxide in the engine cylinder, and combine with the water vapor of combustion to form sulphurous or sulphuric acid. The exhaust gases should never be cooled to the condensing point of water, which would cause corrosion. As the exhaust gases issuing from the engine are hot (600 deg. to 1000 deg. fahr.), the exhaust pipes are jacketed and water-cooled in the proximity of the engine to make work around the engine bearable to the attendants and to prevent burns.

It is customary to provide a test cock in the exhaust pipe near the cylinder head. By holding a piece of white paper over this cock determination can easily be made as to whether combustion is perfect or incomplete. The exhaust should be colorless.

Storage of Fuel Oil

As Diesel plants use about one-third the quantity of fuel oil consumed by efficient steam plants, the storage capacity can be proportionately reduced. In the engine room are one or more small fuel-supply tanks, usually of a capacity to run the engine for half a day. In small installations, a hand-operated fuel pump is used to refill the small fuel tank with fuel oil from the main fuel-oil storage tanks. In larger installations a motor-driven pump is used. Whenever the viscosity of the oil is such that it will not flow readily through the pipes at ordinary temperatures, means to heat the oil to increase its fluidity sufficiently have to be provided. The usual method is to pass the hot jacket water through pipe coils in the small fuel tanks, or to have these tanks provided with water-jackets, through which the hot water from the engine jacket is passed. Provision then has to be made for another smaller fuel tank, in which gas oil (ignition oil) for starting the engine is stored; this is switched on when the engine is to be stopped for any length of time. The fuel supplied to the pipe leading to the engine fuel pump or pumps is controlled from either supply tank by a three-way cock.

When the fuel oil contains sand or other foreign matter, small filter tanks are provided; the fuel oil from the small fuel-supply tank flows through these filter tanks into the main fuel-supply pipe to the engine fuel pump through two branches (one from each filter tank) controlled by a three-way cock. This arrangement permits switching one tank off the circuit for cleaning while the other continues to supply the engine with fuel. As an additional safeguard, filter plugs are placed ahead of the intake valves of the fuel pumps.

The fuel tanks are supported on brackets or a platform on the wall opposite the engine and high enough above

it for the fuel to flow by gravity to the engine fuel pumps. Usually each engine is supplied from its own small fuel-supply tank.

Cooling Water

For cooling the compressor and the engine a constant flow of water, adjusted to the engine requirements, is desirable. This is best supplied from a constant-head tank, which should be at least 20 feet above the water inlet to the engine, so that the head of water will overcome any vapor tension of the steam formed within the engine jackets.

In some engines the water is first passed through the after cooler and the intercooler and the water-jackets of the compressor, then through the engine-cylinder jackets, and last through the head; in others independent water connections are used, with branches from the main supply pipe to the compressor and the different engine cylinders. Although the quantity of water required for cooling the engine is so much larger than that needed by the compressor that it is not warmed appreciably by passing through the later first, an independent water supply to the compressor has much to recommend it, affording easier adjustment of the supply of cooling water to the different cylinders and heads. Separate discharges for the water from the cylinders and from the cylinder head should be provided, each with its own thermometer, so that the temperature in a cylinder or in the head can be controlled. The discharge pipes should be provided with valves, to regulate the discharge, as the water is under pressure.

In large installations, all the water-discharge pipes are brought to a central discharge point and mounted on a switchboard; a cock regulates the overflow, and a thermometer, mounted on the board above each respective discharge, indicates the temperature. A master valve controls the main supply to the engine. When the engine is to be shut down, only the master valve is closed, the other valves being left in adjustment.

Some care must be used in adjusting the supply of water to the engine needs, and an excess should be avoided, as it will cool the cylinders too much; they will contract, whereas the piston, being hot, will expand. Excessive cooling may thus cause piston seizures.

When the engine is stopped, the water should be continued in circulation for some time, as the heat stored in the piston, the cylinders, and the cylinder head is considerable, being sufficient to bring the water to the boiling point, so that sudden stopping of the circulation of the water might cause the cracking of a cylinder or of the cylinder head. If the water is hard, lime or magnesia salts may be deposited and interfere with the efficient cooling of the cylinder head and the cylinders, set up internal stresses, and lead to cracked heads and liners. When the water is hard, the best policy is to use distilled water, which should be cooled before use. The loss with an efficient cooling system need not be more than 10 per cent of the volume of water needed for cooling—amounting to one-fourth to one-half gal. of water per hp. hr.

The volume of cooling water required varies with the size and type of the engine. Engines having a four-stroke cycle use from 2.7 to 4 gal. of cooling water a hp. hr., the larger volume corresponding to smaller engines. Two-stroke engines use from 5 to 6 gal. a hp.-hr. The volume used depends on the initial and the terminal temperature of the water. The figures given are based on an initial temperature of 50 deg. F. and a discharge temperature of 160 deg. F. It is well to plan on not less than 5 gal. of water per hp. hr. for an engine having a four-stroke cycle, and not less than 8 gal. for an engine having a two-stroke cycle. The capacity of the circulating pump should be 50 to 100 per cent larger, depending on the type of pump used.

Mechanical Efficiency

The air compressor, furnishing the injection air and usually driven direct from the engine, consumes considerable of the total power of the engine (7 to 15 per cent) and this loss must also be deducted to ascertain the net effective output of the engine.

The mechanical efficiency of a Diesel engine is influenced by numerous factors, such as the type and the size of engine, the quality of the material and workmanship, the care given to details in erecting, the lubricating system, including the quantity and the quality of lubricating oil used, the engine speed, and the volume of cooling water used. If too much cooling water is used, frictional

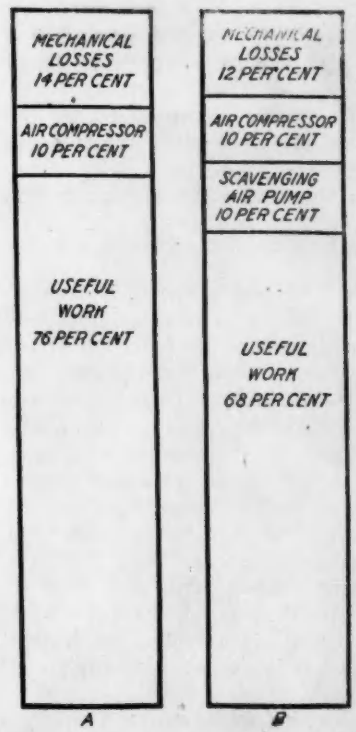


Fig. 6—Distribution of Power Losses in Two Types of Diesel Oil Engines

A, engine having four-stroke cycle; *B*, engine having two-stroke cycle

resistance due to cylinder contraction may be greatly increased. It is always higher in new engines, until the different moving parts have worn the rubbing surfaces smooth.

As the internal power and friction of an engine are nearly constant regardless of load, the mechanical efficiency decreases with a decrease in the engine load.

The mechanical efficiency of engines having a two-stroke cycle is lower than that of engines having a four-stroke cycle, as, in addition to the power required by the injection air compressor, there is that required by the scavenging pump.

The mechanical efficiencies of four-stroke engines at full load vary from 75 to 82 per cent, 80 per cent being usual for high-grade, low-speed engines of medium and

large powers. The engine efficiency, exclusive of the air compressor, is 85 to 90 per cent.

The mechanical efficiency of engines having a two-stroke cycle seldom exceeds 70 per cent and may be as low as 65 per cent in high-speed engines. The distribution of power losses in two-stroke and four-stroke engines is shown in Fig. 6.

Thermal Efficiencies

The thermal efficiency of a Diesel engine is the ratio between the equivalent in heat units of 1 hp. and the number of heat units actually consumed by the engine in developing 1 hp. If based on the indicated horsepower, it is the indicated thermal efficiency, E_{ti}; if on the brake horsepower, it is effective thermal efficiency, E_{te}.

$$E_{ti} = \frac{550 \times 3600}{778} \times \frac{IHP}{WH} = 2545 \frac{IHP}{WH}$$

$$E_{te} = \frac{550 \times 3600}{778} \times \frac{BHP}{WH} = 2545 \frac{BHP}{WH}$$

In the foregoing expressions, 550 foot-pounds per second = 1 hp.; 778 foot-pounds is the mechanical equivalent of 1 British thermal unit; W is the weight in pounds of the fuel consumed during 1 hour; H is the heating value of the fuel in British thermal units per pound.

If WH is the fuel consumption per horsepower-hour, expressed in British thermal units, then $E_t = \frac{2545}{WH}$

The thermal efficiency depends chiefly on the thermodynamic cycle of the Diesel engine, and is affected by the compression ratio (ratio between total cylinder volume and clearance volume at the end of compression) as well as the cut-off ratio (ratio between cylinder volume at time fuel valve closes and volume at inner dead center of piston or clearance volume).

The indicated thermal efficiency increases with a decrease in the cut-off ratio which contributes to the phenomenal economy of the Diesel engine at fractional loads, the fuel consumption per horsepower-hour remaining nearly constant between full and three-fourths load, and increasing only slightly at one-half load. The ignition of the fuel could be effected at lower pressures, but high compression is essential to high engine economy in Diesel engines.

The mechanical efficiency of the engine naturally influences its fuel economy (thermal efficiency) also, but to a minor degree.

The indicated thermal efficiency of the Diesel engine having a four-stroke cycle varies from 45 per cent at full load to 47 per cent at half load, and the effective thermal efficiency from 37 per cent at full load to 30 per cent at half load, which represents the best practice. As regards engines having a two-stroke cycle, the figures are 10 to 15 per cent lower.

Volumetric Efficiencies

The construction of the engine, its piston speed, its valve gear, and temperature are factors that influence the volumetric efficiency. To determine the volumetric efficiency of engines having a two-stroke cycle, it is not sufficient to know the pressure of the air that fills the cylinder (before compression begins); this value must be multiplied by the percentage of pure air present in the total weight of gas filling the cylinder.

For slow-speed four-stroke engines a volumetric efficiency of 90 per cent can be reached, which decreases to 85 per cent for high-speed engines, and for extreme speeds may be even lower. These values presuppose high-grade engines with mechanically operated valves.

At higher altitudes the specific duty of Diesel engines decreases appreciably, owing to the lessened density of the air, which affects the engine just as a low volumetric efficiency would. The horsepower rating of the engine decreases 3 per cent for every 1000 feet of added altitude. Nearly 40 per cent of the power loss could be recovered by precompressing the rarified air to atmospheric or slightly higher pressure in positive-pressure blowers and filling the engine cylinders with this air. Blower equipment is considerably cheaper per horsepower of capacity than Diesel engine equipment. At high altitudes it may pay, under certain conditions, to install blower equipment for precompressing the air for engines having a four-stroke cycle. An engine having a two-stroke cycle can compress the air readily by using a larger scavenging pump.

Characteristics of High-Speed Engines

Low-speed engines are preferred for hard, continuous duty. They have a piston speed varying from 600 to 800 feet per minute, increasing with the power. The number of revolutions per minute varies from 250 to 150, decreasing with the size of the engine. The stroke-bore ratio varies from 1.3 to 1.9, the higher ratio being preferred for low-speed engines for hard service, although with an increase in piston speed the stroke-bore ratio decreases; likewise the number of revolutions.

High-speed engines have a piston speed of 700 to 1000 feet per minute, a stroke-bore ratio of 1.0 to 1.3, and an engine speed of 250 to 350 revolutions per minute. The speed of engines for special purposes, as for submarines, is often increased to 500 and 600 revolutions per minute with low stroke-bore ratio to obtain a light engine of low height.

The mean effective pressure should not exceed 100 lb. per sq. in. at full load and is preferably kept around 90 lb. for hard, continuous service. The engines are designed to carry safely momentary overloads of 20 to 25 per cent, when the pressure will go as high as 120 and 125 lb. per sq. in. Engines having a two-stroke cycle, in which the number of fuel combustions is generally double that in engines having a four-stroke cycle, are designed to operate with a lower mean effective pressure —between 65 and 70 lb. per sq. in.—with a margin for increasing the specific duty of the engine for short periods.

Desirable Properties of Petroleum Fuel

A desirable petroleum fuel for Diesel engines should have the following properties:

1 It should burn completely without leaving any residual matter in the cylinder, either in the form of soot, coke or ash.

2 It should be free from mechanical impurities which might clog the fuel pipes, the valves of the fuel pump, and the fine fuel passages in the fuel-injection valves and nozzles, or might cause excessive cylinder wear.

3 It should be sufficiently fluid at ordinary temperatures to flow readily to the fuel pump and thence to the fuel-injection valve.

4 It should be free from water, as water lowers the heating value of the oil and may prevent its ignition.

5 It should be free from highly volatile oils, which will evaporate at ordinary temperatures and form an inflammable mixture with the air, thus introducing a fire hazard.

6 It should have a high heating value.

To determine the suitability of petroleum products as fuels for Diesel engines, they should be classified by tests as to the following properties, stated in the order of their importance:

1 Boiling-point range, 2 ash content, 3 mechanical impurities, 4 heating value, 5 water, 6 coke, 7 asphalt, 8 paraffin and 9 sulphur content. 10 Acidity, 11 elementary composition, 12 viscosity, 13 flash point, 14 burning point and 15 specific gravity.

The distillation is conducted at atmospheric pressure between the following temperature ranges: 0 to 150 deg. C.; 150 to 200 deg. C.; 200 to 250 deg. C.; 250 to 300 deg. C.; 300 to 350 deg. C., and 350 to 400 deg. C.

As a general rule the smaller the proportion of residue remaining at a temperature higher than 400 deg. C., and the greater the volume of vapor coming over between 200 and 400 deg. C., the better is the oil suited for use in Diesel engines. A further valuable criterion of the burning qualities of oils that leave residues or "oil tars" at temperatures higher than 400 deg. C. is the quantity of coke left on distilling the residue at temperatures higher than 400 deg. C. The greater the quantity of coke the less suitable is the fuel. Fuel oils with a coke content cannot be used in all engines, and a content of 5 per cent may be taken as the upper limit for all engines.

It has been noted that some crude oils having a high proportion of constituents that produce coke and asphalt and yielding an unusually large proportion of residues at temperatures higher than 400 deg. C. decompose (crack) at temperatures between 300 and 400 deg. C. This feature is particularly noticeable in certain California oils and Mexican oils. Such an oil is unsatisfactory for Diesel engines, as only a comparatively small part of the oil is readily burned, a large part being changed to coke; the coke particles contaminate the film of lubricating oil, fill the space between the piston rings and cover the piston, making lubrication ineffectual, causing increased cylinder wear, and requiring frequent cleaning of the engine.

Lubricating Oils

Two kinds of oils are used for the lubrication of Diesel engines—bearing oil and cylinder oil

Bearing Oil

Bearing oil is used for the lubrication of the main, the crank-pin and the piston-pin bearings, and of the camshaft bearings, and for the oil baths into which the cams and the camshaft dip. A pure mineral oil will fill these requirements if it has a maximum viscosity of 7 deg. Engler at 50 deg. C., if it does not congeal at a temperature higher than —10 deg. C., and if it has a flash point of 180 deg. to 200 deg. C. The oil should be entirely soluble in benzine, forming a clear solution without any residue; also, it should be entirely free from acids, resinous substances, and vegetable matter.

Cylinder Oil

Cylinder oil is used for the lubrication of the working cylinders and the air-compressor cylinders. It should be stable at the relatively high temperatures of the piston and the cylinders of a Diesel engine, and should maintain the desired lubricating properties at these temperatures; it should not vaporize readily, nor should it decompose at a temperature lower than 300 deg. C.

A suitable cylinder oil should have a viscosity of 9 deg. to 10 deg. Engler at 50 deg. C., and should flow at —5 deg. C. Its flash point should not be below 240 deg. C. It should be a pure mineral oil free from asphaltum and pitch and resinous substances, and should be completely soluble in benzine, leaving a clear solution without any residue. A piece of sheet brass covered for 24 hours with the oil, at 100 deg. C., should remain perfectly bright and show no action by acids, nor should it be gummed by any substance. A thin layer of the oil spread on the sheet of brass should contain no solid particles perceptible to the sense of touch.

Even the best oils will become partly oxidized in the compressor and engine cylinders and form complex pitch-like substances and insoluble compounds, which absorb fine metal particles from the compressor cylinder or dust that is carried into the cylinder with the air. With good oils it takes many months to form such accretions, and their harmful effect can be entirely avoided by a periodical inspection and cleaning of the cylinders.

Locomotives

The Diesel engine has been applied to railroad traction in two forms; directly in a Diesel locomotive, and indirectly in an electric motor car with a generator driven by a Diesel engine.

A 1000-hp. locomotive has been built by Sulzer Brothers of Winterthur, Switzerland, in which power to the drivers is transmitted direct from a reversible Diesel engine with a two-stroke cycle. For starting, compressed air, furnished by a compressor operated by a separate Diesel engine, is used. The locomotive made satisfactory test runs in hauling freight and passenger trains, but no detailed performance data are as yet available.

Variable-speed Diesel engines coupled to generators and built into passenger railroad cars have been used in several instances in Europe with great success. The fuel consumption varied from 0.8 to 1.2 lb. per train-mile, with a train weight (two cars) of 30 to 66 tons (2000 lb.). The average fuel consumption amounted to 2 to 2.75 lb. per 100 ton-miles. On a basis of 1 kw. hr. being generated with a fuel consumption of 0.7 lb. of oil, this is equal, in round numbers, to 3 to 4 kw. hr. per 100 ton-miles, or 30 to 45 watt hours per ton-mile, a remarkably good performance.

Ship Propulsion

An increasing number of ships are being fitted with Diesel engines. Lloyd's Register for 1914 listed 27 ocean-going ships equipped with Diesel engines with a total of about 40,000 shaft horsepower. At least 20 more ships equipped with Diesel engines were then building. There are probably more than 400 ships, including river craft not listed, fitted with Diesel engines, not counting submarines so fitted. Up to 1914, 6000 indicated horsepower, equal to about 4600 to 4800 shaft horsepower, in six single-acting cylinders and in one engine was probably the upper limit in size, although double-acting engines of 12,000 hp. in three cylinders for use on ships are being tested on the European continent.

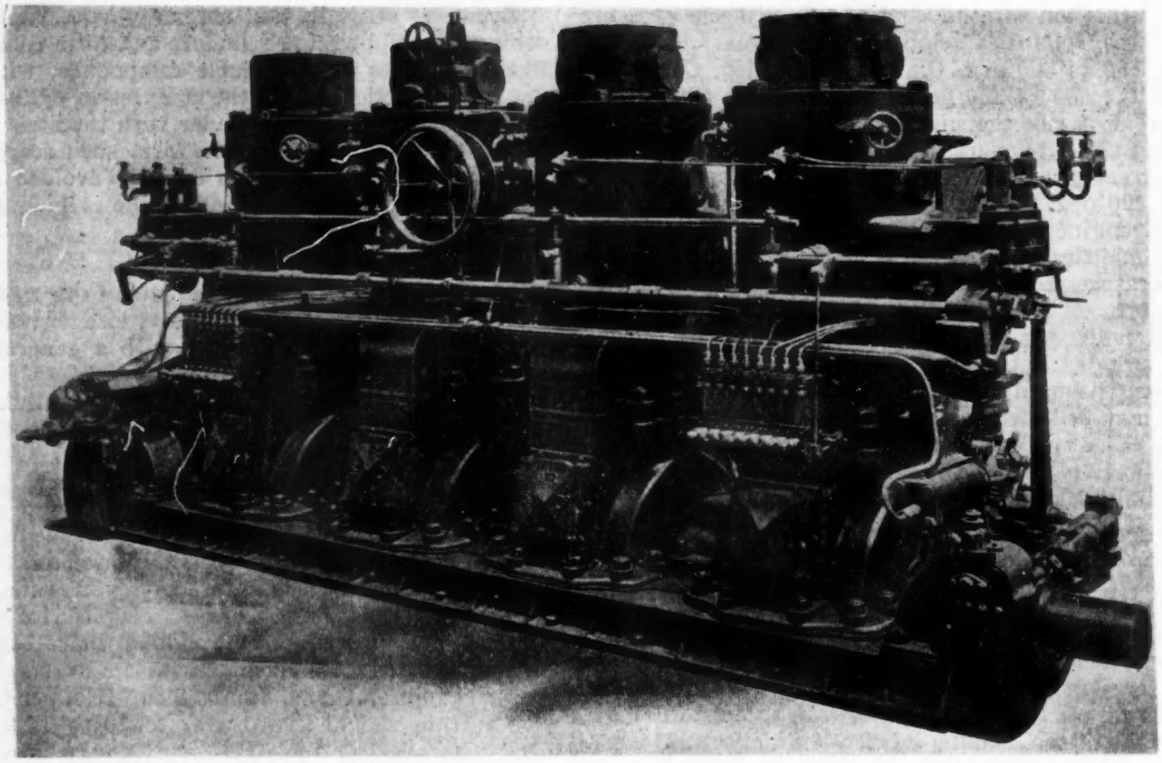
Before directly reversible marine Diesel engines had been developed, reversing and slow-speed changes were accomplished by the Del Proposto system, first used on the Russian ship *Sarmat* in 1904, and subsequently installed in many Russian river boats and ships of the Russian navy. The engine was used for driving the

ship ahead, but for reversing was coupled to a generator and a motor was used. The engine speed could be reduced from 240 to 72 revolutions per minute.

Later, Hesselmann developed a directly reversible four-cycle marine engine, which has been used with great success in many ocean-going ships. Late development favors the engine with a two-stroke cycle for marine purposes, as it can be built materially lighter per horsepower, is mechanically better adapted for reversing, and occupies much less space than other types. Compressed air is used for reversing both types of engines.

The advantages of ships equipped with Diesel engines lie not merely in the greater cruising radius obtainable with a given quantity of fuel, but in the increased cargo space made available, as the liquid fuel can be stored between the double bottoms of the ships, in dead space otherwise filled with ballast water.

The importance of Diesel engines for propelling submarines is commonly known. The latest types of submarines with their greatly increased field of action and cruising radius are almost wholly due to recent improvements in the marine Diesel engine.



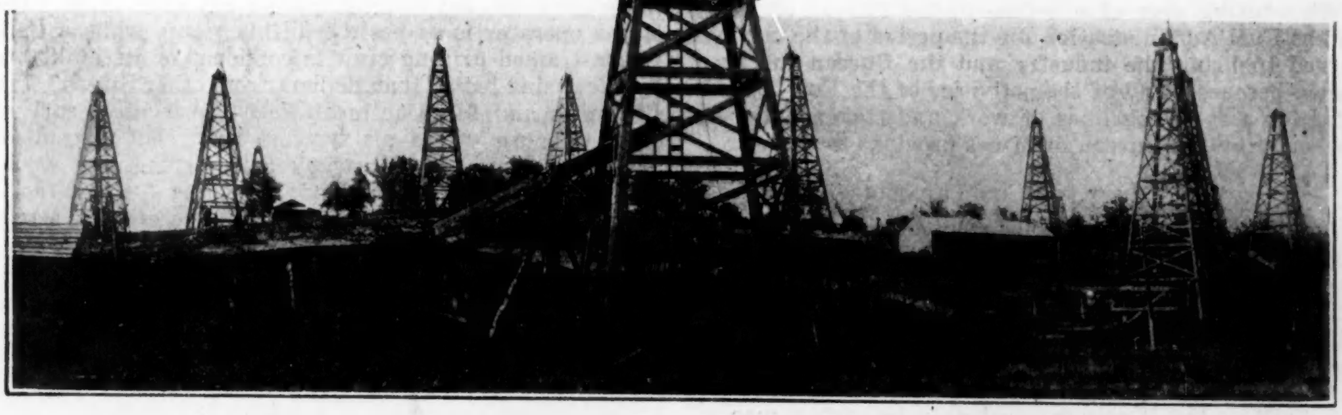
A British Type Semi-Diesel Engine

MILITARY BLIND LABOR

EVERY manufacturer faces the possibility of seeing some of the men who have grown up in his business and gained their experience doing his work blinded in battle and made apparently unfit for further service. Most of these men will, however, be far from unfit, and many of them can be re-educated and made effective. The Red Cross Institute for the Blind proposes to make a survey of every industry in the United States to determine which are suitable occupationally for the blind. There will thus be made available a labor supply which may help to speed up the essential industries and perhaps tide some of the less essential industries over the war.

The primary purpose of the survey is to determine the proper course to pursue in training the military blind. In carrying it out, the plants will be picked that are best organized and equipped in their line. The survey in each plant will consist of a very careful study of the organization, the routing of the material and the requirements for every occupation within the organization. The plan for doing this has been worked out by the Society of Industrial Engineers and several consulting efficiency engineers. The same general plan will be followed in each survey. In the occupational analysis that is planned sufficient attention will be paid to the various details to enable a central commission to select the most practical forms of industrial work for the discharged blind soldiers.

Some General Observations on the Petroleum Industry*



AT LAST, after more than four years of world horror, distress and sacrifice, involving millions of people, the curtain is now being drawn upon the bloody scenes of the greatest conflict of civilization.

Today there come before us, filled with trying difficulties, the problems of rehabilitation and reconstruction, problems that will require the best cooperative judgment of the strongest men in the industries. At this time it is well worth while for us as Americans to recall the part that will go down in history as characterizing American courage and the American spirit. It is the story of our boys who by their heroism, and the way they have finished the job, have made it possible for you and me to discuss here peacefully and with reason the readjustment of the industry you represent, which in itself has played such an important part in winning the war. The one lesson that is again made new and emphasized by our success is that cooperation in the fullest measure is vital to all accomplishment. This indomitable and cooperative spirit of the soldier in the trenches of war must be the spirit of the man of today's strife in competitive business. A wholesome cooperation is imperatively needed, a cooperation which shall include the Government, the States, business men, artisans and laborers. The Government is interested because national security compels a wise policy in the conservation of those of our resources which are limited in quantity.

From a viewpoint wholly commercial, I must assume that you who represent the oil industry have already considered a combination of interests to engage in export trade. If not, I suggest the thought for what it is worth.

A study of the political and commercial control of the petroleum resources of the world presents some interesting facts. That the rest of the world is anticipating a renewed effort for trade and a greater development is seen in one instance in the formation of the Société Minerals et Metaux (Society of Minerals and Metals), which was organized at the suggestion of the French Ministry of Commerce and Industry, and has for its principal objects:

The commerce of ores, metallurgical products and metals;

The establishment of close relations with the mineral and metallurgical industries of the Allied countries;

The development in France of the mining and metallurgical industries.

This company has been organized with a capital of 10,000,000 francs, and comprises among its shareholders twenty-six French mining and metallurgical interests in France, Spain, Mexico, Algeria, Tunis, Serbia, Chile, Bolivia, Italy and Russia. The society proposes to establish research work on a large scale.

Cooperation Between Bureau of Mines and Petroleum Industry

To make a survey of the petroleum industry as a whole is a very considerable undertaking even when the industry and its allied industries are operating under normal conditions, but to presume to delineate the probable courses that it may take in its many phases at the present moment is a much more uncertain task. The industrial world is in a transitional stage, converting its efforts from those of war to those of peace, and in many cases this does not mean resuming the pre-war undertaking, but reorganizing business to meet conditions such as have never before existed.

Many of you have been associated in government work; in fact, through the various functions of the Fuel Administration and the Petroleum War Service Committee it has been your duty and pleasure to carry on in an intensified way certain undertakings which in pre-war times were functioned in part by the Bureau of Mines. The full scope of the Bureau of Mines in relation to the oil industry has never received such full recognition from the oil industry as now. With the appointment of these special war committees, it was found that much of the information needed was available in various governmental departments, and this Bureau has been able to play its part.

*From an address by Van H. Manning, Director of Bureau of Mines, before the Reconstruction Conference of Industrial War Service Committees, in Atlantic City, Dec. 4.

Upon the declaration of war I immediately had prepared a résumé of the status of the industry as it existed at that time and presented the facts before the first Petroleum War Service Committee. Six months later, with the organization of the Oil Division of the Fuel Administration, I arranged with Mr. Requa to give him all the support possible, since he was equipped with the authority to enforce regulations granted by the Lever Bill, a power which none of the regular federal departments possessed.

This taking over of activities of the Bureau of Mines by the Fuel Administration for the period of the war has served to bring the industry and the Bureau in closer touch, because many of the activities of the Fuel Administration were along lines of work undertaken with less authority by the Bureau of Mines previous to the war.

Necessity for Conservation

Coincident with the establishment of the various war service organizations, the need for intensified conservation of the Nation's material resources became apparent, and since that date "Save Food," "Save Coal," "Save Gasoline" have become accepted slogans. Yet when the Bureau of Mines, in cooperation with the representatives of the different automobile societies, issued the first "Save Gasoline" poster, it was frowned upon by certain men of the oil industry as unnecessary. At that period of the war, conservation was unfortunately interpreted by certain factors of the industry to mean restraint of business, but recent events have justified the wisdom of the conservation propaganda which was first started by the Bureau of Mines and later intensified by the Fuel Administration.

I do not make this comment in a spirit of complaint—for I aim to be ever mindful of the trying situation which the oil men faced in the early days of the war when business was adjusting itself to a war basis; their record of accomplishment speaks for itself. At the same time there are some among us who have habitually criticised most government Bureaus as being wild, untamed agencies, bent upon making trouble for the business man for no constructive purpose.

Congress has directed the Bureau of Mines to conduct inquiries and scientific and technologic investigations concerning the drilling, the preparation, treatment and utilization of petroleum and its by-products, with a view to improving health and sanitary conditions, safety, efficiency and economic development, and conserving resources through the prevention of waste. Let me here revert to the emphasis I have already placed upon the cooperation essential to accomplish anything worth while and national in scope, for it is only with your help that the results of our labors can be fully realized. I can judge of the value of the remedial recommendations which the Bureau makes only by the final adoption of them by the industry. I have been gratified by the results obtained in some of the fields.

Possible Technical Research Work

In addition to considering the possibilities in improved commercal efforts, and that there may be a continuous supply of petroleum products for the longest possible period, and that these same products may be utilized to bring the greatest net returns to the operator and to the Nation, as well as the greatest good to mankind, I also ask you to look forward into the realm of possible technical research in some of the branches of the petroleum industry.

It is conceded the world over that American drilling methods are superior to all others, but do we use our knowledge to the best advantage? Two radically different methods are in vogue in this country—the cable and the rotary systems. Each has its advantages and its limitations, and it must not be presumed that one or the other is superior under all conditions. But, unfortunately, prejudice, the load that the industry has carried as a super-tax for many years, plays an important role. The Pennsylvania driller believes that he knows more about the art of drilling than any other man. The Texas operator is as positive in his views, while a California-trained drilling crew is confident of its ability to handle casing better than drillers from other States. The Wyoming and Mid-Continent fields serve as a sort of clearing-house where all systems meet, but prejudices persist. In opening a new oil field an engineer would ask, "What is the best method of drilling for this territory?" but how often does this question receive the attention it deserves from the managers of operating oil companies?

I do not propose to start a technical discussion on the relative merits of the different methods, but desire to point out that the decision is usually left to a superintendent who (1) favors some one system, (2) aims to utilize drilling equipment at hand, or (3) prefers to contract the drilling of the wells, often leaving to the contractor the choice of any method he may desire. This is not a reflection on any one concern, or perchance a negligible percentage of the operators; it is often the practice of large companies equipped with engineering staffs. I hold no brief against contract drilling *per se*, but the practice of placing contracts with firms that will undertake to do the work for the least money, neglecting all other conditions, is unfortunate.

The engineers and expert drillers of the Bureau have for several years been circulating in the fields, consulting with the operators and demonstrating the methods reccommended, to the end that in many places the results speak for themselves. Drilling methods, however, still offer many opportunities for improvement.

I need not do more than call your attention to the sometimes wilful, sometimes unintentional waste incident to the handling of flush productions in many oil and gas fields where the losses occur at the surface of the well. You are all familiar with these, and the engineers of the Bureau of Mines in cooperation with some of the more progressive operators have been studying possible methods of increasing the recovery of oil from the sands. As from 50 to 75 per cent of the oil in a formation is never brought to the surface, it is obvious that opportunity exists here for unstinted research work.

Utilization of Oil Shales

Still looking into the future, I want to fix your attention on the time when the economic balance of supply and demand, adjusted to corrections for transportation differences, will make it necessary for us as a Nation to develop our greatest of all petroleum reserves, the oil shales. Many prominent oil men still fail to realize in any measure the part that the oil to be derived from shale distillation plants is destined to play. The Interior Department has endeavored to point out this immense supply, the Geological Survey having mapped and described large areas in the West, and the Bureau of Mines has been carrying on laboratory experiments for some time to secure additional information as to the richness and possible recovery of oil and ammonia from shales in dif-

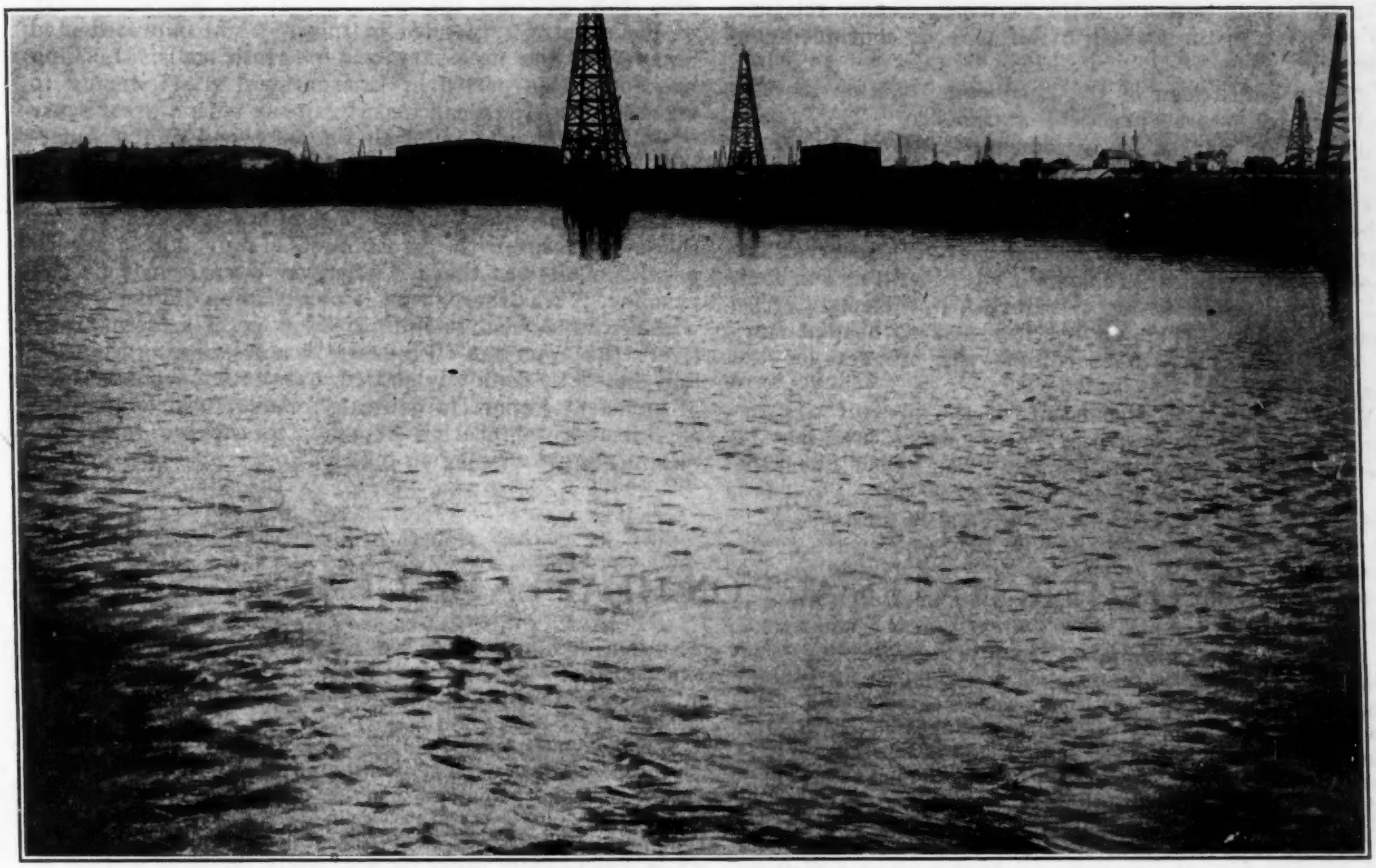
ferent localities. Moreover, during the past year our engineers have assisted in the erection of two small commercial units where tests will be carried on during the coming year. Two of the Bureau engineers have been abroad recently looking into the different phases of the art of retorting shale and coals, including a study of the Scottish shale industry.

Prospective investors in making a careful survey of the situation should bear in mind (1) that the oil shale industry is *not* comparable to oil-well development and does not promise large immediate returns on a small investment, and (2) that it is in reality a large manufacturing enterprise including large-scale operations in mining, crushing and retorting to produce the crude materials, oil and ammonia water. Large and expensive additional equipment will be needed to refine the oil and produce the ammonium sulphate.

Bearing in mind the heavy first cost of this equipment, it must be remembered that operating expenses will be proportionately large and the profit per ton small, requiring a large tonnage to make the venture profitable. Company reports that have been submitted to the engineers of the Bureau have not been strong in data as to the *definite* market for these products. In years to come this will be a factor of much less importance, but at the present time a concern should be equipped to develop a ready market for all its products and be financially prepared to withstand not only competition from near-by petroleum fields but also from other shale oil plants. This is a plain statement of fact, meant not to hinder but to protect the investor and the shale oil industry, for the Bureau of Mines is already busily engaged in studying many problems and plans, to be in position to still further encourage the substantial development of an industry which in years to come will be a very great economic factor.

The Foreign Supply Situation

Now a few words in regard to our position in the entire petroleum situation. The United States has for some years produced approximately two-thirds of the world's supply of petroleum. This statement in itself is very comforting and a remarkable record of achievement. Every oil man here knows or should know, however, that this vast production has been a heavy drain on our natural resources and the direct result of a most thorough combing of our national supply by the concentrated efforts of both practical and oil men backed by large expenditures of capital. Transportation facilities were either immediately available or existing markets warranted their creation. When similar facilities are provided for the undeveloped fields of Mexico, Venezuela, British Columbia, Russia, India, Egypt and possibly other countries of South America and Africa, our position in regard to the world supply is certain to be changed.



An Open Pond of Oil Which Is Worth Over $1,000,000

This fact is not new to us, nor is it new to the powers of Europe, and, furthermore, the powers of the world are also well aware of the importance of petroleum in terms of the world's commerce. I am now bordering on questions of international import, but petroleum is power in every sense that coal is power.

With the present rate of yearly increase in the consumption of petroleum products, it is self-evident that the day is not far distant when the American oil industry must participate actively in the development of foreign

fields. This all points to keen commercial rivalry among the nations of the world, and that we may play a part commensurate with our position in the work and retain our present high place as a producer in the petroleum industry, it is essential that the different factors of the American industry be equipped with a working agreement that is uniform in all essential particulars.

It is not my duty to point out ways and means, or to do more than remind you of the need for these, but in order that relations between the petroleum industry and the Government may be all that is desired, to the end that the Government will be a unified force behind the industry and the industry can best serve the Government, I invite you to perpetuate the existing friendly relations by reposing in the Bureau of Mines your continued confidence.

The technical men of the Petroleum Division all have had several years' practical experience. The expert drillers have worked in various oil fields of the world, the refinery engineers have been employed in both the construction and operation of refineries, and the other technical men have had experience in their own lines of work. It is very evident that such men can appreciate the practical problems of the operators; in fact, the oil man's worries are the Bureau's problems. These men are in the various oil districts, making headquarters at stations serving to coordinate the progress of the various fields.

With the gradual disbanding of the present war organizations and the return to a peace status, laws may be needed. Heretofore, the Congress has called upon the Bureau of Mines for advice in framing certain laws, and in order to advise properly it is necessary that we be alive to the exact situation. For the benefit of the industry the Bureau of Mines should be closely in touch with the problems and ideas of the industry; should know its needs and realize its aims.

Oil Administration's Achievements

The work of the oil administration under the direction of Mr. Requa and his able assistants, augmented by the Petroleum War Service Committee, is coming to an end, and I speak with some authority when I say that the work has been well done. Backed up and guided by this able staff, not only the industry but the entire citizenry of the country responded in splendid and unprecedented manner to the necessary and patriotic calls. Looking back over this period of international crisis, trying to visualize the Herculean task, I can say with a great sense of satisfaction and relief that I am proud of the American oil industry, and proud of the American citizen in his wonderful demonstration of patriotic cooperation. Wherever our Navy needed fuel oil or gasoline, it was there. Wherever the great fleet of our Allies needed petroleum, it was there. Wherever our aircraft needed gasoline, it was there, even if our citizens did have to go without Sunday automobiling. How great a factor, relatively, the American oil industry was in winning the war, may never be definitely settled, but we know that it was of sufficient import to cause a famous British admiral, at a recent jollification banquet, to exclaim fervently, "We floated to victory on oil."

OTHER STATES ACT ON HEADLAMP GLARE

SEVERAL States have taken action to regulate the amount of light thrown by automobile headlamps. In Massachusetts the State Highway Commission has adopted a modified rule which provides that sufficient light shall be thrown ahead to show any persons, vehicles or substantial objects upon the roadway straight ahead of the motor vehicle for a distance of at least 150 ft. It is also provided that the light thrown directly ahead or sidewise shall be arranged so that no dazzling rays from it or from any reflector shall be more than 3½ ft. above the ground on a level road at a distance of 50 ft. or more ahead of the vehicle.

In Rhode Island the State Board of Public Roads, which has the power to adopt without legislative action such regulations as are necessary to govern headlamps is now considering the elimination of the glaring headlamp problem. Although nothing definite has been decided at present, it is expected that any action will conform closely to that already in force in Connecticut and Massachusetts, the States on either side.

The superintendent of police of Pittsburgh, Pa., has started a crusade against automobiles equipped with improper headlamps, and the campaign will be continued to enforce the law already on the statute books to suppress the glaring headlamp. The Connecticut law, the strict enforcement of which has recently begun, is practically the same as that in force in Massachusetts except that the reflected light must not be higher than 42 in. at a point 75 ft. ahead of the vehicle instead of 50. A pamphlet has been sent out by the Connecticut Commissioner of Motor Vehicles containing the names of approved headlamp reflectors.

AMERICAN ENGINEERING MISSION TO FRANCE

AN engineering congress was held at Paris last month under the auspices of the Société des Ingénieurs Civils de France and the French Government. This gathering was supplementary to a preliminary convention held last March. An intensive discussion of maintenance and construction of roads, development of water power, inland waterways, ports and other subjects intended to include every phase of reconstruction and rehabilitation, particularly of the devastated areas of that country, formed a part of the program. This congress was attended by an advisory committee of nine American engineers appointed by the American Society of Civil Engineers at the request of the French engineers. The personnel of the committee is Major J. F. Case, assistant to the president American International Corporation, New York City; George W. Tillson, consulting engineer to the president of the Borough of Brooklyn, New York City; Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, New York City, and expert in city planning; A. M. Hunt, consulting engineer, New York City; George T. Swain, chairman Boston Transit Commission; George W. Fuller, hydraulic and sanitary engineer, New York City; Charles P. Main, consulting engineer, specializing in the construction of industrial buildings; L. B. Stillwell, consulting electrical engineer, New York City; and E. G. Spillsbury, consulting mining and metallurgical engineer, New York City. All of the members are prominent in their respective fields.

The Opportunity of Aviation

By William B. Stout* (*Member*) Buffalo Section Paper

With the end of the war aviation is facing a tremendous opportunity. Present planes are as impracticable for commercial use as were the first automobiles, and the very highest type of airplane existent today is only at the curved-dash Oldsmobile stage of development. Real airplane designing, we may take it for granted, has hardly begun. With the ending of the war the public, already astounded by the tremendous achievements of airplanes in war, is expecting further achievements from these same planes in peace pursuits. The public will not be surprised if within a few months an aerial taxi may be ordered for Shanghai and arrive at its destination in a few hours. Air travel appeals to the imagination and great things are expected from it.

Those directly familiar with the airplane of today and its limitations, are however, inclined to the opposite opinion, and rightly so, seeing but small immediate commercial use for the plane as it is.

The two real fundamentals absolutely necessary in airplanes for commercial work are—safety and cost. Neither of these items has been considered of importance in the development of the last four years. The end of the war, therefore, finds us with war planes only, and it is small wonder that the manufacturer and those familiar with the running expenses of present planes are dubious as to immediate aircraft commercial activity. President Kettering has stated, I believe, that he can see no future for the airplane until it gets down to a cost of not over $5 per hp., and with this we must all agree. The point from which we must start in our analysis, however, is that the public is tremendously interested and is waiting to be carried by airplanes; manufacture with its tremendous investment and, perhaps, past losses, is confronted with the necessity of making aviation pay. Yet there is at present no machine which the manufacturer can make and sell at a profit; none, that is, within a limit that the public can buy and use with safety and in sufficient numbers to support the industry. Everything hinges then at the present time on the activity of the engineer and his genius in creating for both public and manufacturer that machine which will fill to the greatest extent the need of the hour. This is the engineer's opportunity.

Difficulties to Be Overcome

Before we can describe in any way a machine or type of machine to meet the demands of peace, we must ascertain what must be overcome. In order to be adopted by the public the airplane must be so developed as to provide a safer method of travel than any other means of conveyance. At the present time even in war training work we have suffered but one death for every 200,000 miles of air travel. This has been under abnormal conditions, and on planes in many cases hastily constructed and inspected. Yet, in safety the airplane already compares favorably with other methods of transportation. I venture to say that motor cars in Buffalo alone have killed and maimed more people in the past year than all the thousands of airplanes we have had flying in America. We are accustomed to the risk of motor cars, and since the newspapers have ceased discussing the usual routine accident, we have dismissed from our minds the fact that it exists, but because the danger in flying visualizes itself so vividly to the average person, aviation must be safer than other means of travel before it can be definitely accepted.

Safety both in the air and on the ground is then the fundamental consideration. In the air it depends, of course, on the strength and permanency of the structure forming the plane. This means not only what we are wont to call the "factor of safety," but such duplication of parts that no one piece in a plane on breaking will let the ship down. At present, if the tie-rod connecting the lower wing-spars shows a defect and gives way, the wings come off the machine in the air and a crash is inevitable. Search should be made for such a structure as will give the present or higher factors of safety (as we have formerly figured them in multiplied percentage of flying load) and other margins of safety, such that if one part fails through a defect another will take its place. This suggests multiplicity in wing-spars and at many other points. Breakage in the air today is, we are thankful to say, a very unusual occurrence. The airplane in its simplest elements contains very few parts and hence should be supremely reliable.

As we think of the danger of air travel, from the fact that we have not "one foot on the ground" according to custom, we often forget its assets of safety, which are inherent once the proper machine is developed. Foremost among these is that of freedom from traffic and from the danger of mistakes in judgment on the part of other flyers. We know the maximum of stress on our plane while it is in the air and cannot encounter anything greater than that. These things are not true of any other vehicle. Possibly the danger of fire is that most serious for those who fly, but for peace uses planes can be made absolutely fireproof; so that this point can be dismissed.

Engine Development in the War

The greatest development which the war has brought in airplanes has been reliable engines. We are now building engines remarkably superior to those built for any industry at the beginning of the war. We have come to weights as low as 3 lb. per hp., including the cooling system which should always be considered a part of the engine. With all this we have obtained engines that will run without overhauling for more hours than they would previously run for life, all of which has had its influence in widening the scope of war uses for planes. We may now consider the engine as reliable in air use as in motor cars under far less throtttle opening.

The chief difficulty with airplanes today is in the connection between the engine and the plane and in those accessories which must be festooned, Christmas-tree fashion, all about the structure to properly notify the pilot of the behavior of his machine. Many more planes come down through the breaking of a gasoline pipe or an oil lead, or the grounding of an ignition wire, than are

*Engineer, United Aircraft Engineering Corporation.

forced to land by what is known as engine failure. Engines today are so reliable that little is thought of flying low over a city, and while some view this kind of flying with horror, yet in low ceiling conditions it is often necessary, and engines and planes must be built to meet such conditions with the proper modicum of safety. We may therefore more or less dismiss engine reliability as an accomplished thing as regards safety in the air.

War planes are not designed to be stable. They have been arranged for quick maneuvering ability. For peace conditions, however, they must be made more foolproof so that the average pilot can fly with greater accuracy and safety than the stunt pilot can do now. To design a normally stable plane is really no problem, the main point being to know just what stability is desired. The safest point is the happy medium which will enable a plane to fly through fog or cloud and keep its level and yet at the same time allow it to recover immediately of its own volition from side slip. It is quite possible to design commercial planes so that the pilot cannot put them into loops or nose-spins, or any quick maneuver, even should he wish to show his skill in these respects. Such planes the experienced pilot will not like, but the public will demand them.

Airplanes, as they now exist, can be easily changed to meet these new requirements of air safety. No special problem exists, and commercial planes, now being designed here and abroad, will have a safety factor of almost 100 per cent. The next problem, however, that of safe landing, is not so simple.

The Landing Problem

Ordinarily we think of safety in landing as primarily one of speed, but as pointed out in a paper read before the Society last summer, there are three fundamentals of landing, (a) speed, (b) area required, and (c) height location of center of gravity (which determines the striking angle).

With a plane of slight resistance and low landing speed an aviator may roll a half-mile after he strikes the ground, thus adding considerably to his danger. He may have a machine with light wing-loading, which can float down very easily but with such acceleration on account of the light loading that if he has to dodge obstacles at the edge of the field, and dive sharply to get into it, he will be up to a high-speed landing before he knows it and possibly slide across the landing field he has selected at his theoretical one foot above the ground, without having reached the slow speed at which the plane will have a tendency to settle. Thus the light-loaded plane might require more space in which to land than one which could land at a higher speed and yet come into the field at a quicker angle. If the center of gravity is high above the landing wheels and the front wheels strike an obstruction, there is a tendency for the wheels to stop and the weight to go on, standing the machine on its nose or turning it through a complete somersault. It should, however, be easily possible with present-day knowledge to design a machine to land at 30 miles per hr. average, and within the space of an ordinary ball park, without danger of actual injury even in the event of having to land in excessively rough ground or to run directly into an obstruction.

The popular idea of a plane that will rise directly from the ground by an overhead propeller, go straight up and come down in the same way, is far from meeting the ideas of engineers in the light of our present knowledge of what is required after it once gets up; no figures of thrust and weight combinations show much possibility of immediately solving the technical points involved. The danger would be much greater in such a type of plane than in those now flying, and it is so much more rational to take what we have and build on it than to try to create something radically new, that the helicopter need not be discussed in this paper.

Possibly the greatest requirement for safety in flying will not be a problem directly for the engineer, but for those communities interested in the commercial development of planes. I refer to the establishment of air harbors or landing fields in our principal cities. There can be no doubt that we are to have a large amount of air travel, and those cities wide enough awake to its promise to establish air harbors and to welcome aviators, will naturally develop as commercial centers for such travel as routes to them become better known to pilots. When every city has its well-marked landing field, safety even with present type of plane will be vastly greater and service equivalently better.

Excessive Cost of Production

Having thus briefly sketched the requirements for safe flying, let us pass to the question of cost. This at the present time is excessive due (1) to the amount of horsepower required per pound of weight carried and hence the extreme cost of the units going to make up the machine, and even more important, (2) to the expense of hangars, landing fields, accessories, mechanics, etc., which are of necessity connected with any flying of present-day ships.

We have, perhaps, been in error in past reasoning regarding airplane design, in looking to the engine for greater economy per mile. Airplanes consist of two factors, the parasite parts, those which in flight resist the air without giving back resultant lift or usefulness, and flying surfaces, such as wings, ailerons and controls, which do perform definite aerodynamic or lifting functions.

Naturally, the wings of an airplane are a most important part, since for every pound of resistance which the engine overcomes in thrusting them through the air they give back an equivalent lift of 18 lb. plus, in the best plane of today. Attached to these wings, however, and performing a structural function only, are the struts, wires, fuselage, radiator and connections, pylons, bomb racks, etc., which eat up horsepower and gasoline without return. The astonishing part is that thus far we have allowed the parasitic effort to be two-thirds of the total expenditure, thus tremendously limiting the performance of planes and impressing upon them the necessity for greater horsepower. At full speed our DeHaviland 4 consumes 237 hp. in its sticks and wires and only 93 hp. in the wings. Another thing, the wing curve of this ship shows a possible lift of close to 20 lb. for every pound of resistance overcome, while the lift-drift ratio of the total machine, sticks, wires and all, is only 8 to 1; 8.4 is about as good as any present-day airplane can do. It is only logical to admit that the eventual airplane will expose to the air only such parts as have aerodynamic functions, and have everything of merely structural function out of the wind, where it cannot clutch at performance and cry for more fuel. In this last year of the war we have been striving for slight gains in performance, a few more miles per hour and a few more miles of distance. The time has come when we must think radically. To obtain the results outlined an entirely new line of

research and effort must be carried through, throwing to the winds some of the old fallacies regarding aerodynamic requirements and thinking new in every particular. In this next step we cannot listen too closely to the scientist whose work is based on reasoning from past performance, but must look forward with vision and prophecy to something really and fundamentally right and new.

In April, 1917, Mr. Gray, editor of the British *Aeroplane*, in an editorial on advice to America regarding airplane design, after complimenting our method of going at production and commercial development, warned us against the academic type of airplane design. "I feel pretty sure," he said, "that America's scientists will assure America's workshop bosses that, if they are given six months more in which to carry on experiments in wind-tunnels and to fiddle with slide rules, they will have Europe's star-turn aeroplanes beaten to a frazzle. Mistrust the scientist with slide-stick promises. Beware of the highbrow with a table of logarithms and calculating machinery. His airplanes generally stop on paper or very near the ground. Insist on performance. Never mind what the scientist calculates. Trust the man who guesses and guesses right. If his machine gets higher than that of the scientist and flies faster, it is a better aeroplane for making war."

After all, scientific wind-tunnel research is more for corroborative than for creative influence. In talking with a man in charge of one of the largest automatic machine-tool plants in America regarding certain airplane development, I mentioned the number of months that had been spent thus far in the wind-tunnel work and calculation. His distress was evident. "I believe," said he, "you are making a mistake. I have made but two big failures in design in my life, and these were the two in which I insisted first on scientific calculations, and on knowing we were theoretically right before we went ahead. In each case we fell down miserably. I have found the better way is to build the blooming thing and after it is done and works, get the logarithms and slide-rule information and write a scientific paper on it. The main thing is to build something; after it is built keep improving it until it does the work."

I believe that the next step in the design of aircraft will come not through the scientist or deeply technical engineer, but through the man who thinks of some new method of obtaining a fundamentally new result, and who by salesmanship rather than engineering succeeds in "putting it over." This new plane must have new performance in order to get low cost, but if, for example, we can merely eliminate the parasite resistance, we can then travel with 100 hp. at the speed and with the load which now require from 300 to 400 hp. We can then, perhaps, use heavier, cheaper engines, and yet carry greater loads than we do at present without expensive structures. Since parasitic resistance is by 1000 per cent the most deterrent factor in airplane performance today, is not this the most important line of research to be followed as the first step?

A plane to meet the new opportunity will probably have new general characteristics of structure as well as new air action. Taking into account storage expense as well as flying efficiency, it will probably have maximum area within minimum dimensions. This must be secured also within a minimum of weight, to ensure safety and cheapness. Aerodynamically it must have a maximum lift per unit of area, and hence will probably be in monoplane form, in which form lift per square foot can be vastly greater than in biplanes at speed, provided a structure can be found for monoplanes which will be as strong in proportion to weight as in biplanes.

Finally, the plane must have maximum strength per unit of weight, and a factor of safety more than just a figure in multiple percentage of flying load. It must be small for housing, and fold for transportation. It should be able to land in a vacant lot, or at least in a ball park.

It should have fuel capacity for at least 4 hr. of individual use, and for a 3000-mile flight in a really feasible transatlantic plane. Before transatlantic flight can be accomplished planes with a lift-drift ratio of ten must be produced—again a problem of reducing parasitic losses. For safety the plane should make at least 90 m.ph. maximum, and land at under 40.

THE DISCUSSION

HERBERT CHASE:—Will you explain what efforts have been made or are being made to eliminate parasite resistance?

MR. STOUT:—Corners must be avoided wherever possible, and exposed struts; braces and wires made as few as possible or enclosed in streamline covering which can often be formed into lifting surfaces. Some of the monoplanes of foreign design have been built with internal bracing. Early attempts were made to use a wing internally braced, with spars in triangular arrangement. Monoplanes, having only two spars have proved dangerous. With internally-braced wings trouble has been experienced in keeping the wing rigid and in preventing it from warping. It is a structural problem, which I believe is capable of solution when a deep wing section is employed and a veneer covering is used in place of fabric.

T. S. KEMBLE:—It is possible to get rid of a very large percentage of parasite resistance. This is one element that is going to aid in making the airplane avaiable for commercial transportation. The question now seems to be, as Mr. Stout has said, whether the engineers who know how to design planes suitable for commercial use are good enough salesmen to convince the public.

C. B. VEAL:—The first necessity is salesmanship. Changes in design must be accompanied by salesmanship. The airplane will, I think, be developed first by making it a sporting machine. What can be done or has been done to improve the safety of the airplane?

MR. STOUT:—One accident for 200,000 miles of flying is the record established at American flying fields. This I believe compares favorably with other means of transportation. A number of items have a bearing upon safety in flight. There are many deficiencies in present-day airplanes. Often if one part breaks a forced landing or dangerous fall is inevitable. I believe we should search for a new mechanical arrangement which will not depend upon one part only; multiplicity of wing spars instead of one or two, for example. So long as we build airplanes with fabric and wire we have a sort of kite. We should aim to get a more reliable type of construction. In a wing of conventional type we build a framework and cover it with fabric which is shrunk on and thus produces an extra strain. The fabric takes away from the strength of the structure. We have material which we are not using for functions it might perform. If, for example, two-ply wood 1/20 in. thick were used on a DeHaviland wing, it would make a more rigid wing. The veneer covering becomes a part of and strengthens the structure.

Plywood is also more nearly fireproof. The problem of fire protection now that we no longer have to consider the

use of planes in battle, is largely one of common-sense construction. The effect of quick changes in temperature upon plywood is, however, not yet known. The next point to study is landing safety. If the center of gravity is high above the landing wheels and the front wheels strike an obstacle, there is danger of the machine turning a complete somersault. Where the center of gravity is low, the plane is in less danger from this. I believe it will be possible comparatively soon to land in one-third the space we require today, for we shall be able to reduce wing loading by the required amount to do so.

During the war we have gained considerable experience in the construction of steel airplanes. There will be no difficulty in making planes with steel framework in the wings if necessary, but such construction if of doubtful possibility without quantity production. For the present, the wood structure is the thing we must stick to, except, perhaps, in the use of steel for propellers. Steel parts will doubtless come into use eventually, but we cannot abandon wood structure at the present time.

THE RELATIVE CORROSION OF ALLOYS*

By R. B. Fehr†

IT is hardly necessary to emphasize the great importance of the problem of corrosion. The large number of technical papers appearing on the subject and the enormous mass of data that has been collected are sufficient evidence of this, but in spite of the time and attention that have been given to the subject by technologists and scientists comparatively few laws have been definitely established, and consequently the true theory of corrosion is still a matter of controversy. The obvious remedy for this would appear to lie in the standardization of methods of testing. Just as there are tension, compression, shear, torsion, bending and fatigue tests for determining the relative strengths of metals under different conditions of use, so too there should be certain standard tests for determining the relative corrosion of metals under different conditions. The ultimate aim should be to devise a comprehensive series of tests to which standard specimens of materials can be subjected and by which the relative corrodibilities of these different materials can be predicted for certain service conditions. Consequently, it will probably be found that a few tests will cover in a qualitative way the most usual conditions that are met in practice.

One of the most important factors that would be involved in any proposed standard method is the time element. To meet the short-time requirement various so-called "accelerated" corrosion tests have been devised, the principal corroding media being sulphuric acid, sea water or other salt solutions. These methods have met with much opposition for the reason that they do not imitate, and therefore cannot intensify, natural corrosive influences, as they were intended to do. The results thus obtained are not in agreement with those obtained under practical service conditions. This is not surprising, for it is now becoming generally recognized that the relative corrodibilities of different materials vary with the nature of the corroding media. What may be highly resistant under a certain set of conditions may be highly corrodible under different ones.

In replying to questions addressed to him on the value of acceleration tests, the Director of the U. S. Bureau of Standards stated that there can be no standard method for testing the relative corrosion of various metals, since corrosion depends not only on the kind of metal but also on the nature and concentration of the corroding agent, and that acceleration tests are of value only if the conditions are produced under which the articles are to be used. Thus, articles to be used in salt air at the seashore or in sea water may to advantage be compared in the "salt-spray" test, but a salt-spray test might give very misleading results if used, for example, in judging roofing materials in a smelter town when much SO_2 is present. Hot-water tests, acid tests, etc., must be interpreted with the utmost care.

Since accelerated tests are not regarded as trustworthy, and also since long-time tests are not feasible, it becomes necessary to adopt some compromise between the 1 or 2 hr. period of accelerated tests and the many years of the actual service tests. Some preliminary tests conducted by the writer led to the conclusion that trustworthy results could be obtained within a period of a few weeks, provided analytical balances were employed and the same care exercised as in quantitative chemical analysis. Of course small test specimens would have to be employed. The objection might be urged that small specimens would not be representative of the material, but duplicate or triplicate samples, combined with greater uniformity of preparation and accuracy in weighing, would more than offset this nominal disadvantage.

Method for Indicating Relative Corrodibility

Experiments run under different conditions with respect to weight, density and exposed surface of the specimens can never be considered strictly comparable. A much better measure of the relative corrodibilities of materials can be gained by applying the following method of reasoning: Suppose, by way of example, that a certain corroding medium gave the results on specimens of different materials having dimensions given in Table 1. This example is a somewhat extreme case, but it sometimes requires an extreme case to emphasize a point. A study of the results given in the last three columns of the table is interesting in that they appear to indicate four, three and two different values respectively for the relative corrodibilities, whereas in reality the four materials have the same corrodibility, as further consideration will easily show.

What really matters in corrosion is the *volume of material removed in a given period of time from each unit of surface*, and not the loss in volume per unit of volume, nor the loss in weight per unit of surface, etc., for these latter methods do not take into account the differences in density and exposed surface of the speci-

*From a paper read before the American Society of Mechanical Engineers, December, 1918.

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mens, which differences are certainly no fault of the materials. For instance, specimen No. 2 has the same density but twice the exposed surface of No. 1. If it were of the same material as No. 1 it would be expected to lose twice the weight, and yet it would be manifestly unfair to say that the relative corrodibilities are different. Again, No. 3 has twice the density of No. 2, and if it had the same corrodibility it should lose twice the actual weight, as well as twice the weight per unit of surface. Therefore, provided all other conditions were the same in these cases, the only method that would indicate equal corrodibility would be the per cent loss of weight method on account of the canceling out of the density factors.

TABLE 1 ILLUSTRATIVE CORROSION RESULTS ON DIFFERENT MATERIALS

Specimen	Weight, grams	Volume, cc.	Surface, sq. cm.	Sq. cm. per cc.	Loss, gr.	Loss, per cent	Loss, gr. per sq. cm.
1	15	3	75	25	1.5	10	0.020
2	15	3	150	50	3.0	20	0.020
3	30	3	150	50	6.0	20	0.040
4	30	3	300	100	12.0	40	0.040

Obviously, then, none of the methods employed thus far indicates the true relative corrosion values for specimens of different sizes from different materials. However, if the results obtained by the percentage method in Table 1 are divided by the respective values for the ratio of surface to volume, the results will be 0.40 per cent of cc. per sq. cm. in each case, and thus a true measure of the relative corrodibility is obtained.

The algebraic derivation of this method is as follows:

Let a = area of *exposed* surface of test specimen, sq. cm.
v = volume of specimen, cc.
d = density of material, gr. per cc.
w = original weight of specimen, gr.
s = loss in weight in gr.
p = per cent loss in weight and volume.
K = measure of relative corrosion by proposed method, per cent of cc. per sq. cm. of surface.

$$p = \frac{s}{w} \times 100 = 100 \frac{\frac{s}{d}}{\frac{w}{d}} = 100 \frac{\frac{s}{d}}{v} = \text{per cent loss of}$$

volume, since the volume equals weight divided by density.

$$\frac{a}{v} = \text{ratio of surface to volume,}$$

and

$$\frac{p}{\frac{a}{v}} = 100 \frac{\frac{s}{d}}{v} \times \frac{v}{a} = 100 \frac{\frac{s}{d}}{a} = \text{per cent of cc. lost per sq. cm. of surface.}$$

Therefore, $K = \frac{p}{\frac{a}{v}}$; that is, the per cent loss in weight (or volume) is to be divided by the ratio of surface to volume.

These values of K will then represent the true relative corrodibilities when the conditions of testing are the same except for the densities and dimensions of the specimens. But to express in the simplest and most easily comprehended manner the relative values of different materials in regard to their *resistances to corrosion,* the reciprocals of the K values should be taken and compared with, say, the highest one, which, for the sake of comparison, may be regarded as having a corrosion resistance of 100 per cent. Thus, if materials A, B, C, and D have values for K of 5, 10, 15, 20 respectively, the reciprocals or resistances to corrosion will be 0.200, 0.100, 0.067 and 0.050; while the relative "efficiencies" of resistance to corrosion will be 100, 50, 33⅓ and 25 respectively.

This new method of expressing relative corrodibilities takes into account the obvious fact that corrosion varies directly as the exposed surface, other things being equal. The time element cannot be involved in any method of expressing corrosion, for it is a well-established fact that corrosion does not vary directly as the time, since the first layers of corrosion products may in some cases inhibit and in others accelerate corrosion. In other words, the duration of all tests that are to yield comparative results should be a constant quantity.

A Series of Comparative Corrosion Tests

It is believed by the writer that careful tests of different sizes of specimens of various kinds of materials run under like conditions will justify the above proposed method of expressing the results, but as yet no such series of tests can be offered. Nevertheless, it may be of interest to report the results of a series of tests that was run for the purpose of ascertaining the consistency of results that could be obtained by exposing small-size specimens to tap water and solutions of sea salt for comparatively short periods of time. These tests are to be regarded as preliminary and therefore the arbitrary conditions adopted will be subject to such future modifications or drastic changes as any inconsistencies in results of these and succeeding series of tests may indicate. A number of commercial alloys were supplied by various manufacturers. The analyses of these alloys, as made by the manufacturers, are found in Table 2.

TABLE 2 ANALYSES OF ALLOYS

	A	*B*	*C*	*D*	*E*	*F*	*G*
Fe	99.840	2.30	98.473	98.697	Trace	67.406	99.647
C	0.010	...	0.780	0.459	....	0.190	0.040
Mn	0.025	1½–1¾	0.594	0.740	....	1.350	0.260
Si	0.005	....	0.065	0.060	....	0.184	0.010
S	0.025	....	0.055	0.035	....	S and P less than 0.040	0.036
P	0.005	....	0.013	0.009	....	....	0.007
Cu	0.050	30.02	....	....	89.84	....	....
Ni	....	65.48	....	....	....	30.830	....
Al	....	....	....	....	9.96	....	....
Ti	....	....	0.020	....	....	....	....

The alloys were supplied in the form of ¾-in. rolled stock, which was turned down in a lathe, and from which were cut disks of fairly uniform size, as shown by the data in Table 3. A ⅛-in. hole was drilled in the center of each specimen so that a glass hook could be inserted for suspending the specimen in the corroding medium. All the specimens were first roughly polished by emery cloth and then finished to uniform surface conditions by rouge cloth. The disks were then washed in ether to remove all grease, dried in a desiccator and carefully weighed on analytical balances.

The following solutions were employed: Tap water, a 0.1 per cent sea-salt solution and a 10 per cent sea-salt solution. To insure uniformity of corroding media throughout the entire series of tests, sufficient amounts of the solution were made up and put away in tightly stoppered bottles.

The tests on the various alloys and three solutions were run simultaneously with duplicate specimens. A 150-cc. beaker filled with 100 cc. of the corroding solution was

TABLE 3 DATA ON TEST SPECIMENS

Average diameter, in.	0.6989
Average thickness, in.	0.1544
Average weight, gr.	7.0940
Average ratio of surface to volume $\frac{a}{v}$	20.0400
Average per cent deviation of $\frac{a}{v}$ from mean	4.6000
Maximum percent deviation of $\frac{a}{v}$ from mean	13.8000
Minimum per cent deviation of $\frac{a}{v}$ from mean	0.1200

provided for each individual specimen, which was suspended in the middle of the solution by a glass hook attached to a short piece of wood resting on top of the beaker. At the end of the 24-hr. test the specimens were removed from the beakers, soaked for several hours in a solution of ammonium citrate to remove the rust, dried and carefully weighed to determine the loss in weight. The specimens were then polished so as to have new surfaces, cleaned, dried and weighed for the succeeding 7-day test, for which new solutions were employed. This procedure was maintained for the 28 and 105-day tests. In all cases the beakers were placed in a glass case, and the daily maximum and minimum temperatures were observed.

Discussion of Results

In expressing the results of these tests, the percentages of loss by weight are given in Table 4, the relative efficiencies of resistance to corrosion are presented in Table 5, the alloy marked *F* being taken as the 100 per cent standard in this case. Alloys *B* and *E* exhibited such a slight amount of corrosion that they could not very well be used as a basis for comparison. Table 6 gives some statistical data of these tests.

Among the points to be noted as a result of these tests are the following:

The most impressive feature is the consistent grouping of the more corrosive iron and steel alloys *A*, *C*, *D* and *G*, as against the highly resistant alloys *B*, *E* and *F*, in which copper and nickel are the most prominent constituents.

TABLE 4 PERCENTAGES OF LOSS BY WEIGHT

(Averages of Duplicate Tests)

	1 Day	7 Days	28 Days	60 Days	105 Days
			Tap Water		
A	....	....	....	....	3.160
B	....	....	0.000	0.007	0.028
C	0.028	0.142	0.494	1.080	1.950
D	0.033	0.165	0.629	1.490	3.390
E	....	....	0.000	0.009	0.029
F	0.012	0.016	0.073	0.170	0.330
G	0.035	0.150	0.597	1.410	3.000
			0.1 *Per Cent Sea-Salt Solution*		
A	....	....	....	....	2.800
B	....	....	0.006	0.021	0.061
C	0.034	0.153	0.449	0.930	1.590
D	0.031	0.183	0.570	1.350	2.750
E	....	....	0.022	0.066	0.216
F	0.022	0.040	0.077	0.134	0.213
G	0.043	0.149	0.530	1.260	2.520
			10 *Per Cent Sea-Salt Solution*		
A	....	....	....	....	1.340
B	....	....	0.0013	0.011	0.062
C	0.026	0.116	0.4660	0.910	1.400
D	0.027	0.123	0.4920	0.920	1.370
E	....	....	0.0340	0.080	0.162
F	0.021	0.065	0.1360	0.192	0.238
G	0.027	0.091	0.3490	0.699	1.170

In the first group it should be noted that the steel *C*, in which titanium is employed as a cleanser, shows considerably less corrosion than the other steels in tap water and weak salt solutions. In the second group the copper-nickel alloy *B* was in most cases superior and in no case inferior to all the other alloys. This was the only alloy that exhibited its original appearance after being cleaned in the ammonium citrate solution.

Perhaps the next most impressive fact brought out by these tests is the decreased corrosion of the more corro-

TABLE 5 RELATIVE EFFICIENCIES OF CORROSION RESISTANCE*

	1 Day	7 Days	28 Days	60 Days	105 Days
			Tap Water		
A	......	......	......	......	10.40
B	......	......	∞	2,430.00	1,180.00
C	42.90	11.30	14.80	15.80	16.90
D	36.40	9.70	11.60	11.40	9.74
E	....	......	∞	1,890.00	1,140.00
F	100.00	100.00	100.00	100.00	100.00
G	34.30	10.70	12.20	12.10	11.00
			0.1 *Per Cent Sea-Salt Solution*		
A	......	......	......	......	7.61
B	......	......	1,284.00	638.00	349.00
C	64.70	26.10	17.20	14.40	13.40
D	71.00	21.90	13.50	9.92	7.75
E	......	......	350.00	203.00	98.60
F	100.00	100.00	100.00	100.00	100.00
G	51.10	26.80	14.50	10.60	8.46
			10 *Per Cent Sea-Salt Solution*		
A	......	......	......	......	17.70
B	......	......	10,460.00	1,745.00	384.00
C	80.70	56.00	29.20	21.10	17.00
D	77.70	52.80	27.60	20.90	17.40
E	......	......	400.00	240.00	147.00
F	100.00	100.00	100.00	100.00	100.00
G	77.70	71.40	39.00	27.50	20.40

*As calculated from Table 4.

sive group of alloys as sea-salt is added to tap water. This effect is not observed in the non-corrosive group of alloys, for the reason that it is probably masked by experimental errors in determining the very slight losses in weight. This decreased corrosion with increased concentration of the salt solution is in harmony with the results of other experimenters.

The commercially pure iron *A*, which was received in time for only the 105-day test, gave very disappointing results, since in all three corroding media it showed practically the same corrosion as the ordinary carbon

TABLE 6 STATISTICAL DATA OF TESTS

Duration of Test, Days	1	7	28	105	Average
Average per cent deviation of per cent loss (p) from mean of duplicate tests	3.21	5.85	4.94	4.22	4.56
Average per cent deviation of values of K from mean of duplicate tests	3.80	5.01	5.25	3.67	4.43
Average daily maximum temperature, deg. fahr.	....	76.20	79.50	78.30	....
Average daily minimum temperature, deg. fahr.	....	65.30	67.40	66.40	....
Highest temperature reached	71.00	84.00	86.00	89.00	....
Lowest temperature reached	54.00	62.00	60.00	52.00	....
Average temperature (estimated)	62.50	70.80	73.50	72.40	....

steels, *D* and *G*. However, in fairness it should be pointed out that rust may either accelerate or inhibit corrosion. If the metal is homogeneous, sound, dense and free from occluded gases, the rust will probably be dense and closely adherent and will thus offer some degree of protection. If the metal is non-homogeneous and contains a considerable amount of occluded gases, the latter upon escaping will cause the rust to become spongy and porous and will

therefore permit the electrolyte to come more readily into contact with the metal. In the case of the practically pure iron *A*, only one test 105 days long was run. Perhaps tests of longer duration would indicate *A* to be superior to *D* and *G*, especially as regards pitting, but for the present it can only be concluded that from the standpoint of loss in weight commercially pure iron is not superior to steel in tap water and salt solutions.

The specimens did not show any pitting, but in most cases, after the corrosion products had been washed off, there remained stains and slight blotches, except in the case of *B*, which showed only a very slight yellow-red stain in the salt solutions, which was easily removed, with the result that the metal showed its original bright appearance. It must be kept in mind that no quantitative method of measuring corrosion is satisfactory in the case of materials that become pitted, for it may very likely happen that a badly pitted specimen may show but a comparatively small loss in weight. Consequently it is always important to accompany the quantitative tests with the qualitative test of the appearance.

A study of the statistical data of Tables 3 and 6 points to the conclusion that when corrosion specimens are fairly uniform in density, area of exposed surface and volume, the method of expressing the relative corrosions by per cent loss in weight gives results as consistent as those obtained by the newly proposed method, for the average deviations of both methods, as noted in Table 6, are practically equal. It should be kept in mind, however, that the use of the new method, in cases where the specimens vary considerably among themselves with regard to density or ratio of surface to volume, will give a much better basis for comparison than any other method.

The relative efficiencies of corrosion resistance indicate that very consistent results can be obtained by the method of testing employed in these series, when the duration of the test is one week or more for the more-corrosive alloys, and about one month or more for the less-corrosive alloys. In fact, one day is quite sufficient to classify groups of alloys in the order of their corrodibility for such corroding media as will cause enough loss in weight to be determined by analytical balances. Nevertheless, before any final conclusion can be drawn as to the best method of testing relative corrosion, more work will have to be done, especially with reference to the results of service tests as compared with laboratory tests similar to those described in this paper. For the present, however, it seems proper to conclude that very consistent results, at least among themselves, can be obtained by using small specimens and refined methods, but without using "accelerating" conditions.

Summary of Conclusions

The conclusions to be drawn from the results obtained may be summarized as follows:

(*a*) Steels and commercially pure iron are very much more corrosive than nickel-steel (containing a high percentage of nickel), nickel-copper and copper-aluminum alloys, in tap water and sea-salt solutions.

(*b*) Titanium-treated steels appear to be somewhat more resistant to corrosion than the ordinary commercial steels in tap water and weak sea-salt solutions.

(*c*) In general, the corrosion decreases as the concentration of the sea-salt solution increases.

(*d*) Commercially pure iron does not show superior resistance to corrosion in laboratory tests of three months' duration.

(*e*) Refined laboratory tests of short duration on small specimens under natural conditions of corrosion can probably be devised to give results consistent with the order of corrodibility as determined from service tests of long duration.

(*f*) The method of expressing relative corrosion by dividing the per cent loss in weight by the ratio of surface to volume should be employed when the test-specimens are not within, say, 15 per cent of the same density or size.

(*g*) The quantitative method of measuring corrosion should always be accompanied by the qualitative test, based on the appearance of the specimen, in order to detect pitting or other irregularities on the surface.

USING VOLCANIC STEAM

MOBILIZING Italy's volcanos is going to save a great quantity of coal. The first experiments along this line were made some years ago near the salt mines of Volterra, a region extensively covered with volcanic formations. The most wonderful are the so-called "soffioni," volcanic vents emitting powerful jets of hot steam containing boric salts and various gases used in the extractions of boracic acid, says the Italian Bureau of Public Information. Instead of limiting the use of these steam jets to extracting the salts contained in the exhalations of these natural vapor vents, the ejection of the steam is stimulated by boring holes. In this way it is possible to obtain powerful jets at a pressure of two to three atmospheres, according to the locality, and in some instances as high as five atmospheres, the temperatures varying from 150 to 165 deg. cent. These jets maintain their force and temperature unchanged for many years, and are not affected when other openings not too near each other are bored in the ground, proving that they do not influence each other reciprocally. In 1905 Prince Ginori-Conti applied this natural steam to a 40-hp engine, using only a small section of the Nenella fissure, which is the most powerful "soffione." The results of several years' experiments were satisfactory.

Three 3000-kw. turbo-alternators have been installed. The natural steam, superheated to 165 deg. cent., issuing from the soffioni was piped to the boilers. The works at Larderello has a 16,000-hp. central plant operating without interruption and distributing current to Florence, Livorno and Grosseto. Its capacity is to be increased. The natural steam available at Larderello and the surrounding country is, it might be said, unlimited.

PLEA FOR UNIFIED HIGHWAY DEVELOPMENT

IN an address delivered by George C. Diehl at a recent meeting of the National Association of Motor Truck Sales Managers, the necessity for a unified control of highway development work throughout the country was pointed out. In his remarks Mr. Diehl said:

The smallest unit of highway administration in a majority of the States is the local town or township, of which there are over 30,000 in the country. Nearly $1,000,000 is disbursed daily on road work by these townships, and in a large measure is expended unscientifically, extravagantly and without securing permanent results.

It would appear that the admitting of the Nation as a unit into road building and the entire abolition of the township unit, with the county the smallest highway administrative unit, would be a long step toward securing connected and well-developed systems, effectively and adequately maintained. It is altogether likely that the county would be an ever-increasing important unit in the actual performance of maintenance work.

No engineering structure, with the exception of the public road, is designed without first knowing accurately the load which the structure will be obliged to carry. There is great uncertainty regarding loads among highway engineers in road designing. A highway is analogous to a railroad in that both are designed to carry traffic, and the general principles which have been evolved from railroad construction apply in a great measure to highways. The railroads rebuilt their lines many times by reason of the increased weight of the rolling stock, but this will be unnecessary in highway construction if the lesson is learned from the railroads, to look far enough into the future in order that a definite and sufficiently large highway load may be established.

A highway with an improved surface 14 to 16 ft. wide and operated to its capacity would admit of but one line of traffic moving in either direction. If motor trucks were operated on a 15-sec. headway, and their maximum carrying-capacity was 2 tons, then it can readily be computed that the entire carrying-capacity of a highway would not be in excess of one trainload daily. If the carrying-capacity of the trucks were increased to 4 tons, the capacity of the road would be practically doubled. Therefore, it would seem to be an advantage to adopt a comparatively heavy truck as a maximum, and even then the highway engineers should design the road with a considerable factor of safety by assuming a still larger load. There would be no difficulty in designing a road sufficiently strong to carry any load which might reasonably be moved over it. It is merely a question of dollars and cents and sufficient appropriation to supply the necessary labor, materials and supervision.

In New York State, which has expended approximately $200,000,000 on highways within the last twenty years, a greater sum by far than any other State in the Union, there are only 4000 or 5000 miles of highway, or about one-twentieth of the total amount capable of accommodating the heaviest truck travel. It is not expected that the heavy railroad rolling stock can be moved over unimportant side lines, nor that large Lake steamers can pass through the small inland waterways, nor should it be supposed that lateral highways can be designed for the heavy motor trucks, but it is entirely possible to lay out a main system of highways between the larger centers of population, sufficiently strong for this purpose, and a secondary system of highways strong enough for fixed lesser loads, except during certain brief periods of the year when the highways are soft, by reason of frost or otherwise.

It can be seen that the construction by the Federal Government of national roads of the most durable type, reinforced concrete or block pavement of monolithic construction, not less than 20 or 24 ft. in width, and in many instances wider, forms the entire basis and backbone of a larger highway and motor truck development.

The appointment of a traffic engineer in the various state and national highway departments, an officer who would not have any duties involving construction and maintenance, but consider traffic problems only, should help largely in this development.

GOOD ROADS

RECENTLY some tests were made in California by the Good Roads Bureau of the California State Automobile Association. These tests were made on different types of road to ascertain the amount of pulling power required to haul a given load. They disclosed the fact in cold figures that it takes 218 lb. of power to pull a 1-ton load on an earth road; on a macadam road it takes 64.3 lb. of power, and on a gravel road in good condition from 78.2 to 81.3 lb. Even on a level earth road, with dust about 1 in. deep, it required from 92 to 99.3 lb. of pulling power to get over the road. On a concrete road the same 1-ton load required only 27.6 lb. of pulling power.

The tests were carefully made under the direction of Prof. J. B. Davidson of the Agricultural Engineering Department of the University of California. They emphasized the fact that when a road required anywhere from 64 to 218 lb. of pulling power to get a 1-ton load over it, the road is costing the community too much. It is a very simple matter to take the difference in power-cost between a concrete road at 27.6 lb. and an unimproved road at 218 lb. and use that difference in paying for the concrete road, on which greater tonnage can be hauled at less expense.

In a recent test in Michigan the amount of gas used on a concrete road to go 10 miles was 1¼ gal. To go the same distance on a country road took 2 gal. 1 gill. The time for going over the 10 miles of concrete road was 42 min. and over the country road 1 hr. 24 min.

The speeds made by a heavily loaded 2-ton truck in another test in Michigan are given in the following table:

Kind of road	Miles per hr.
Concrete	16.4
Gravel	9.5
Dirt	4.6

On main market roads or trunk lines in and around large centers of population at least, we must stop building gravel, water-bonded and penetration macadam. Scientific tests and data secured from different sections of the country, as well as cold logic, lead us inevitably to the concrete road, a type which offers least resistance to the easy movement of wheels, is not slippery, is dustless and mudless, is easily and cheaply maintained and durable.

Cracks and pit-holes in the concrete must be kept filled, shoulders macadamized or graveled, drainage structures periodically cleaned out, weeds kept cut, sign-boards erected, danger spots marked; railroads must be urged to keep crossings in good repair, guard rails must be erected along the right-of-way at dangerous turns and curves, broken brick replaced, dust-layers applied where necessary on gravel or macadam, and every effort made to prolong the life and usefulness of our roads with a minimum of inconvenience to traffic.

—E. N. Hines in *100%*.

Vol. IV January, 1919 No. 1

Scrap Organization and Scrap Salvaging

By Lieut. Charles A. Reagan*

Mid-West Section Paper

ANCIENT alchemists sought to turn the baser metals into gold, not understanding that transmutation is chemically impossible, but the scrap industry has solved the problem from another direction, and scrap is transmuted into the gold that industry is willing to pay for, service in presenting the scrap in form and condition to be used again. Some things once used are lost forever in that form and must pass through Nature's laboratory to become available again for man's use. Steel, iron, copper, bronze, lead and other metal scrap need no such lengthy cycle, but can be made available again at once and reappear in valuable form through one of the metallurgical processes which first made it of use.

Once the ore has been reduced to metal and made into some form of useful article, this metal can continue to the world's end to serve man unless it be lost in the depth of the sea or isolated in a position where the final cost for its reclaiming is too great to make such recovery possible.

Since it is the reclaiming of material temporarily without use or value to the man, it is true conservation. It reduces the drain that would otherwise be made on the mineral wealth in the ground and staves off the day when this will be exhausted. Probably in no other line of conservation is the reclamation so complete. Coal burned is lost as coal and continues to exist only as gas, ash and power. Wood is burned or rots away and cannot be reclaimed, but metals continue as metals and do not lose their identity as such, no matter how many times they are used.

Magnitude of Scrap Reclamation

From the junk collector of the alley to the dignity of the raw material from which ships, armament, guns and shells and the finest grades of steel are made, seems a far cry, but in the main road and the byways lurk many a story of interest to all who desire to have a full understanding of the greatest business of the country, the production of iron and steel in its myriad forms for peace and war. Without the use of scrap it might easily come about that war preparations of the Government would fail to be sufficient for its need.

In connection with this, through the Stores and Scrap Section of the Ordnance Department, we have reclaimed, in the Chicago District which covers the Middle West, many hundreds of thousands of tons of turnings and borings and many tons of heavy melting, low-phosphorus and nickel steel scrap; copper, brass, aluminum and other metals are carefully segregated and sold at the full maximum prices fixed by the American Iron & Steel Institute, which money has gone directly into the Treasury of the United States.

There has been installed in a great number of plants doing ordnance work what is known as a stores organization, consisting of a chief stores inspector and his assistants, known as checkers. All material which the Government is either furnishing direct or for which it is reimbursing the contractor is checked on receipt by these men, who make out Material Received reports which show

Where received	Charges paid or unpaid
Date received	Car record, if desired
Name of contractor	Quantities
To be used on contract number	Units
	Gross and net weights
Name of consignor	Description of material
Point of shipment	Condition, good or bad
Received via	Purchase order number
Shipping date	Where stored

This also has to have the approval of the inspector as to quality and the approval of the stores checker as to quantity before the U. S. Accountant can pay or issue vouchers covering payment for this material. All direct materials, indirect materials and tools which are used in the manufacture of the article contracted for should be stored subject to the approval of the stores inspector, and no raw material should be placed in the storeroom until the inspection division has passed on it as to quality and attached thereto an inspection tag. This will relieve greatly the congestion in the storeroom and the mixing up of material that would not pass inspection and should not have been received with that material which is satisfactory. The material not passing inspection should be immediately returned to the supplier and no record made on the card inventory of its coming in and it will, therefore, not be taken into account of manufacturing purposes.

Storage Of Material

All materials should be kept neatly in bins or on shelves or racks, and on the floor only when absolutely necessary. Large castings, forgings, bars, sheet steel, etc., which cannot efficiently be kept in the storeroom, may be placed elsewhere but should be plainly marked for identification.

All materials which are used directly or indirectly in manufacturing should be obtained from the storeroom upon a stores requisition, showing by whom requisitioned, what the article requisitioned actually is in a plain description, the number of pieces wanted and signed by the receiver of the material. All tools, gages, jigs and fixtures either purchased outside or manufactured at the plant should be entered on the tool inventory card and be placed in the toolroom immediately. Care should be taken by the storekeeper against undue depreciation, injury or loss of tools, the method being such that tools lost or stolen could be charged against those responsible. The stores inspector, on the call of the factory manager, should account for everything on the inventory by a new, partly used, or broken tool, and all broken or useless tools thus received should be scrapped or otherwise destroyed, and the quantity so disposed of listed and checked by the storekeeper on a list certified by him, and the corresponding quantities dropped by the record department from the inventory cards.

Scrap Segregation Brings Higher Prices

Scrap should be very carefully segregated and I have installed in the various plants a set of cards covering each kind of metal used in manufacturing operations, with a separate color for each kind of metal. One of

*Chicago District Manager, Stores and Scrap Section, Ordnance Department.

these cards is placed on each machine operating on that kind of metal, so that a man gathering up the borings, turnings and other refuse material will know exactly what they are, and upon taking them out of shop will find on the various receptacles a card of the same color, so that if he is a foreigner and cannot read the English language he can at least compare colors.

By this proper segregation of material a much greater amount of money can be realized from the sale of scrap. If the scrap buyer has to spend time and money in segregating this material, so that it can be used by the smelters and refiners, the supplier of the scrap is the one who has to pay for the labor. Large amounts of materials are scrapped which should not be scrapped, and, therefore, a proper salvage department should pass upon all scrap before it is disposed of as such. For example, one particular firm was carrying over $200,000 worth of stock on inventory sheets the same as cash, which was practically obsolete as far as they were concerned. By proper salvage and disposition, the material was turned into money and they now have the money in the treasury instead of still in stock and taking up valuable storage space of no service to them.

A man to have the knowledge to run a stores organization and scrap salvaging department must have information regarding the qualities necessary to pass inspection, and the materials necessary to keep up production, and be able to assist the inspection and production departments in getting the material ready for and to the place at which the manufacturing operations are to be done. Proper stores organization, which covers the delivery of material to the machine and also the taking away of this material to the storeroom, should also include proper record-keeping of the articles upon which manufacturing operations have been completed and are awaiting assembly of the finished unit. Many times manufacturers desire to know just how many parts they can turn out in a given length of time and how many articles it will be necessary to manufacture. If the stores organization is run properly, they will be able to give this information on very short notice.

Problem of Handling Personnel

My method of handling the personnel successfully has been to try to place myself in the man's position, getting as close a grasp as possible of the different conditions he has to contend with and the class of men with whom he comes in contact, and in putting questions to him regarding general conditions which would show the attitude of the contractor and also the other officials in charge of the work at that plant. I always make it a point to see the storekeeper first and do not discuss any of the situations until he is present, getting his side of the story first. There will be some little difficulty at times, but by endeavoring to make the men feel that you are with them and for them, you will get good work, which is absolutely necessary in the efficient operation of the stores department. The head storekeeper must study the situation at all times and have a thorough knowledge of the practical applications of the storeroom.

I have found that a great deal can be done in handling the personnel of the stores department by mixing with the workmen and checkers and assistant storekeepers, as they, very evidently, will be able to tell you many things which you should know, and I feel that if one follows those ideas and principles he will have no trouble at all in handling the stores organization and scrap salvaging department and the personnel successfully.

After-War Readjustments

For upward of a year and a half, American industries were engaged 90 per cent in the production of war material. Signing of the armistice and the collapse of the Teutonic empires swept this activity away over-night, but it is impossible to restore 100 per cent normal peace outlet over-night, and its return must be gradual. The healthy condition of our national balance sheet, which shows that our assets—consisting of natural resources, the country's productivity and our finances—are sound as can be, augurs a much earlier return to normal conditions than is generally anticipated.

Cessation of war demands has left the waste material industry in a perhaps somewhat more complicated position than the manufacturing industries. Not only must we retrace our steps, like the latter, and cater to hundreds and thousands of ultimate consumers instead of to the Army and Navy which we served while hostilities were on, but, in certain lines of war material manufacturers, stoppage of activity in this direction implies the accumulation of large quantities of scrap and waste which cannot be fully absorbed and digested until these industries themselves are back upon a peace footing. This cannot be accomplished over-night nor will it take years, as some of the pessimists would have us believe. It is safe to say that it did not take the industries of the United States more than six months to accomplish the transition from peace to war pursuits, and, in view of the demand for peace commodities fully as urgent now as then for war stores, it should take less than six months to get back to normal.

BAN ON HIGHWAY WORK LIFTED

THE United States Highway Council announces that no further applications need be made to it for approval of highway projects as was formerly the case, that previous disapprovals are revoked and that pending applications require no further action. Normal practices should be followed in securing highway material and transportation for it. It will also be unnecessary for the State highway departments to submit programs for 1919 work to the Council.

Highway bond issues, which are under the control of the Capital Issues Committee, are not affected by the removal of these restrictions.

FRANCE

FRANCE'S spirit has been that of a heroism that could not admit the possibility of an hour so bitter that she would falter. There was no faltering. In that darkest time, in July, this year, just before the breaking of a new day, when the Germans believed Paris to be within their grasp, France grimly took up new resolves and consecrated herself anew to the task of exerting all her "force to the utmost" until the enemy should be beaten.

When the moment came, France struck and with her there struck the might of America, the power of Britain, the firm will of Italy, and indomitable Belgium and brave Serbia.

MEMBERSHIP COMMITTEE CHAIRMAN'S MESSAGE

WE are rapidly approaching the time when all members should check their membership standing with the National Society of Automotive Engineers.

Some of you have been passive members and undoubtedly very busy with your private affairs, with no time for the consideration of future engineering problems. You who have been actively in touch with Society matters are to be congratulated. You already know that engineering problems, with the cessation of the war, will be of a character entirely different from that prior to the war. Automotive engineering will undoubtedly be fundamentally changed under the influence of ideas collected during the period of the war. This is already evidenced in the progress made in automotive apparatus developed under war pressure. A lot of things are sure to be changed—although not of necessity fundamentally, because the buying public will be considerably more critical hereafter of the design and quality of the goods they receive. Those of you who have kept in touch with current events realize this. Only by the active participation of our entire membership in Society affairs can we hope to be ready for the "Big Show."

The chairman of the Membership Committee has written repeatedly to those of you who have cooperated by sending in prospective member cards. It is no small matter to check these up to see if the prospect suggested has given a decided "yes" or "no" to his invitation. Membership in our Society is an asset; only through the endorsement of going members do prospects ever attain the connection. We would like to complete our current roster as quickly as possible. With this end in view, I am asking, through the pages of THE JOURNAL, that every active Society member who has been addressed by the Membership Committee make a point of following his prospect. This is sometimes a difficult thing to do we know, but write him a letter, call him up on the telephone or drop into his office, and put the matter to him squarely. Tell him it is your belief that he is entitled to membership in the Society and point out its advantages. It is your job to get a decision from him.

Another point I want to bring out is this: Not one-tenth of our members have application cards or forms of the S. A. E. parent body in their desks or close at hand, so that they can present them at opportune times to such of their visitors as are entitled to membership. If you would see to this, you would be surprised to find how many are delighted to be approached on the subject. They have held aloof from our activities simply because they have not considered themselves eligible. We wish to enroll all who are eligible for membership. Our constitution is very clear as to who these are—practically all workers in the automotive engineering and closely allied fields, with exceptions of course, as outlined in the rules governing the Society.

I want to impress this upon you now. Will you not, in the next few days, make up your mind you are going to do your part? C. C. HINKLEY,

Chairman, Membership Committee.

AMERICAN SOLDIERS

I SAW American soldiers on the boats, in their cramped and crowded quarters, many of them away from home for the first time; all but a few of them on the ocean for the first time in their lives. I saw them in Paris, unconcernedly playing ball in the streets while bombs from long-range guns were exploding in the immediate neighborhood. I saw them in French ports, and in villages throughout the fair land of France, cheerily taking things as they came, the rough with the smooth—and there was a good deal more rough than smooth—making friends with the kids, and, especially in the case of the fair sex, with the grown-ups too. I met them as foresters in the extreme south of France, near the Spanish frontier. I met them as engineers and in numberless other capacities. Finally, I saw them as fighting men at the front, and met many of their leaders, from the great chief, General Pershing, down.

I saw in the French ports, in our huge camps and bases, and along our lines of communication, the simply marvelous work which these men had already accomplished and were doing with a bigness of vision, a boldness of planning, a directness of attack, a perfection of execution and a courageous assumption of responsibility, which would have done credit to renowned captains of industry.

Everywhere, among officers as well as men, I found the same simple and unostentatious, yet steel-clad determination to hold life cheap for the honor and glory and safety of America; everywhere the same eager, tireless exertion and keen, quick-witted adaptability; everywhere the same modest and soldierly bearing, the same uncomplaining endurance under hardships and discomforts, the same contempt for danger. There was in, through and over it all, a splendid courage, moral and physical, willing discipline and service, buoyant good nature and humor, and clean and kindly thought and feeling. OTTO H. KAHN.

OIL A BIG FACTOR IN HALTING GERMANY

THE lack of a sufficient amount of petroleum products by Germany was one of the chief reasons, according to the oil experts of the U. S. Fuel Administration, for the sudden termination of hostilities. In the past, Germany had drawn her gasoline supply and the larger part of her oil principally from Roumania and Galicia, while a small amount of these supplies was being derived from German crude. Aviation gasoline was derived from the Roumanian and Galician crude. The effect of the armistice with Austria was the stoppage of all traffic between that country and Germany, with a consequent almost complete cutting off of the oil supplies so necessary for the prosecution of hostilities. Products of coal and various volatile fluids have undoubtedly been utilized for internal-engine combustion fuel, while the cracking process and the synthetic process of passing hydrogen over hot carbon were employed to meet the demand. The supplies of lubricating oils and kerosene were also at the point of exhaustion, and sometimes oils of all kinds were almost unobtainable except for strictly military purposes. That these supplies have been failing for some time is evidenced by the sporadic efforts of the submarines and the lack of activity in recent months of German aircraft and tanks.

Lubrication and Fuel Tests on Buda Tractor Type Engine

By P. J. Dasey* (*Member*)

Mid-West Section Paper

Illustrated by Curves

THE demand for heavy-duty engines of the four-cylinder, four-cycle, vertical type, especially for use in farm tractors, has made it necessary to make alterations in design with the idea not only of strengthening such parts as are under maximum load conditions during practically all of the operating period but also of allowing for adjustments to shaft and connecting-rod bearings with the least loss of time and effort.

The Buda HTU model engine illustrates late development in medium size, four-cylinder engines produced for use in farm tractors and heavy-duty trucks.

In exterior appearance it differs from the conventional type only in the detachable head and split oil-pan, two features that are highly valuable in tractor work where the excessively heavy duty makes it necessary that access to cylinders, valves and crank bearings be easy as well as rapid.

The general dimensions of the engine are as follows:

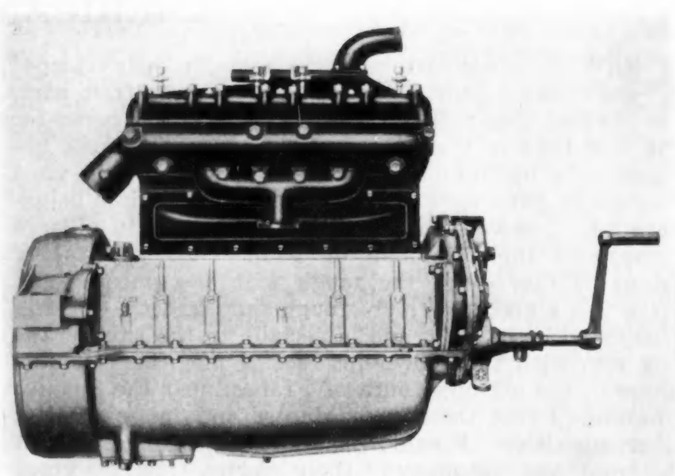
Type	4-cylinder, vertical, in bloc L-head, 4-cycle
Bore	4¼ in.
Stroke	5½ in.
Approximate weight, with regular equipment	800 lb.
Suspension	Three-point
Carbureter	1¼ in. vertical outlet
Lubrication	Geared pump force-feed system
Cooling	Centrifugal water pump
Extreme length of crankshaft	32 1/16 in.
Height from center of crankshaft to top of water outlet pipe	25¼ in.
Distance from center of crankshaft to bottom of engine	9 11/16 in.
Distance from center of front supporting bracket to center of rear supporting arm	34 3/16 in.
Drop of supporting arms from center of crankshaft to top of frame	4 to 6 in.
Drop of front support bracket	2½ or 3½ in.
Length of rear supporting arm	25¾ in.
Length of engine over cylinders	24⅞ in.
Diameter of flywheel	17 in.
Weight of truck flywheel	76 lb.
Weight of tractor flywheel	115 lb.
Face of flywheel	3½ in.
Flywheel regularly furnished for multiple-disk clutch.	
Diameter and length of front bearing	2⅛ x 3⅛ in.
Diameter and length of middle bearing	2¼ x 2¾ in.
Diameter and length of rear bearing	2⅜ x 4 in.
Diameter and length of connecting-rod bearings,	2⅛ x 2½ in.
Connecting-rod length from center to center	12¼ in.
Number of connecting-rod bolts	4
Diameter of connecting-rod bolts	7/16 in.
Diameter and length of piston-pin bearings	1⅛ x 2⅛ in.
Length of piston	5⅜ in.
Effective working diameter of valves	1⅞ in.
Piston displacement	312 cu. in.
Internal diameter of bell housing flange	16⅛ in.
External diameter of bell housing flange	17¾ in.
Diameter of bolt circle	16⅞ in.
Diameter of bolts	⅜ in.

The split oil-pan is a feature which has proved highly valuable in practice, as it permits of the bearings being examined and adjusted without the necessity of removing the transmission from the bell housing.

The valve timing is as follows: Inlet opens 15 deg. past top center and closes 40 deg. past bottom center, while the exhaust opens 45 deg. before bottom center and closes 10 deg. past top center.

While this valve setting has worked out well in practice it has not by any means been determined that it is the most efficient; hence further experimentation is being carried out which it is hoped will ultimately determine what change if any is necessary in the timing to secure maximum results in the use of fuel as well as in life of valves.

The intake valve areas have been designed for the high velocity of the ingoing mixture. At 600 r.p.m. the velocity is 6033 lineal ft. per min.; at 800 r.p.m., 8044; at 1000 r.p.m., 10,055, and at 1200 r.p.m. 12,066 lineal ft. These figures are based on calculation only. The vacuum readings at the same speeds are at 600 r.p.m. 0.45 in.; at 800 r.p.m. 0.80 in.; at 1000 r.p.m. 1.25 in., and at 1200 r.p.m. 1.60 in.



A Medium Size Four-Cylinder Engine Recently Developed for Farm Tractors and Heavy-Duty Trucks

The waterpump is of the ordinary rotary vane type with a capacity of 4½ gal. at 400 r.p.m.; 8½ gal. at 700 r.p.m.; 11 gal. at 900 r.p.m., and 14 gal. at 1200 r.p.m.

The projected area of the wrist-pin bearing is 2.39 sq. in. (1.125 in. by 2.125 in.), carrying a total pressure of 2001 lb., or approximately 837 lb. per sq. in. The projected areas of the main bearings are: front main bearing, 6.7 sq. in., load approximately 720 lb. per sq. in.; center main bearing, 6.18 sq. in., load approximately 780 lb. per sq. in.; rear main bearing, 9.49 sq. in., load approximately 518 lb. per sq. in. Total of all main bearings—22.37 sq. in. with an average pressure of 672⅔ lb. per sq. in. Ratio to piston displacement 13.5 to 1.

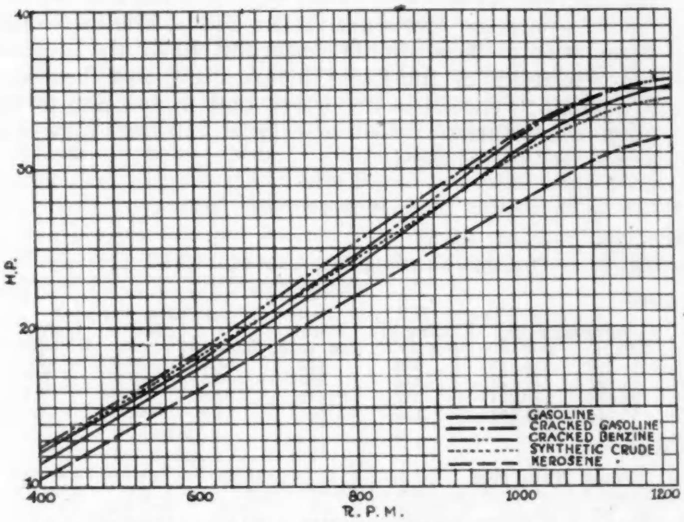
*Sales and Research Engineer The Buda Co.

The connecting-rod bearings each have 5.31 sq. in. with a pressure per sq. in. of 908 lb.

The valves have semi-steel heads electrically welded to 0.20 carbon, 7/16-in. diameter stems. They lift 5/16 in. and have 1⅞-in. diameter in the clear. The camshaft, 1 in. in diameter, and cams are turned out of solid bar, cams being ¾ in. wide. There are three bearings of ample proportions.

The crankshaft is made of 0.45 carbon open-hearth steel; the connecting-rods of 0.25 carbon open-hearth steel.

A pressure lubrication system is used which forces the lubricating oil to all crankshaft, crank-pin, wrist-pin and camshaft bearings, the pressure ranging from 0 to 30 lb. at 1000 r.p.m.



Horsepower Developed at Different Speeds by Four Fuels

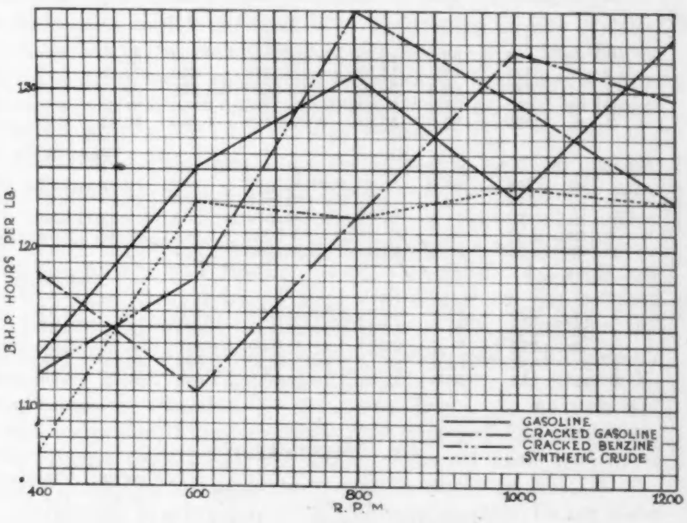
The pressure is furnished by a gear pump mounted on the bottom and at the rear end of the oil-pan and driven by spiral gears mounted on the cam and pump shafts. The oil is carried in the oil-pan and before reaching the pump must pass through a bronze wire screen mounted near the center of the oil-pan, after which it enters a passage leading to the intake side of pump. From there it is forced up a passage-way leading to a tube which runs the length of the engine and from which passage-ways lead to the main and camshaft bearings. From the main bearings the oil is fed to the crank-pins through holes drilled through the crankshaft and from the connecting-rod bearings to the wrist-pin bearings, through copper tubes clamped to the sides of the connecting-rods. The cylinders are lubricated by the oil thrown off the connecting-rod bearings at the crank-pins, while the cams, push-rods, tappets and valve-stems are lubricated by oil thrown by the cams and cranks to the guides above.

A relief valve is provided in the main oil line at the front of the engine so that when the pressure reaches the point at which the spring is set to operate, the ball check is raised and the oil flows into the front gear-case, thus furnishing a constant supply of oil to the gears. To hold a constant reservoir of the oil in the gear-case a small dam is cast across the outlet so that the oil level is always above the bottom of the gear mounted on the engine shaft.

Lubrication

In connection with the work already accomplished in the designing and working out of the full pressure system described considerable work has been done to determine what kinds of oil are best suited for use in this type of engine. Internal-combustion engines of this type have two major conditions in lubrication to meet at the same time and with the same oil, namely, cylinder lubrication under high heats and pressures, and lubrication of crankshaft and connecting-rod bearings under comparatively little heat but high pressure. The lubricant must have the necessary body and viscosity at 150 deg. fahr. to withstand the extreme pressures in the crank-pin and main bearings without permitting the metal surfaces to come in contact; also its viscosity at 350 deg. fahr. must be such as to provide a perfect piston seal, and to bear the pressures exerted against the piston and cylinder walls, under very high heat conditions, with the minimum of cracking or decomposition of the oil. The oil must not only have these characteristics but must be fluid at reasonably low temperatures, although for pressure-feed types the cold test is not as important, so far as feeding the lubricant in cold weather is concerned.

As a general rule oils of low gravity crack under lower temperatures and pressures than do oils of higher gravities, the result being more rapid consumption of the oil, partly as fuel, partly in the formation of carbon deposits in the cylinders, and partly in the increase of the heavy tarry ends washed down into the reservoir. The more a given oil decomposes the less its value as a lubricant becomes. Some of the heavier vapors condense and are washed down with the heavy tarry ends, thus raising the gravity (making the oil lighter), and lowering the flash and fire points to a considerable degree. This condition makes rapid consumption of the lubricant unavoidable and causes considerable difficulty with carbon deposits on plugs, cylinders, pistons and rings. If continued in use for any great time the crankcase oil will become a thick tarry mass, too heavy to circulate freely and dangerous to use.



Power Developed per Pound of Fuel

The lighter gravity oils are usually subject to a higher degree of evaporation and a lesser degree of cracking; hence to get a satisfactory lubricant that will serve both cylinder and bearing conditions with the least decomposition, maintaining with the highest flash and fire points and the viscosity from which the best average results can be expected, characteristics have been tabulated.

Oils specified for summer use only are much heavier in body than those specified for all-year service, and

while they may be used in summer only because of their remaining in a fluid condition, they will carbonize more freely than the lighter oils. They are more viscous, however, and will carry the loads placed upon them with less wear of the bearings than the lighter oils. It is a matter of choice which oil one uses, all things considered. One reason for not using heavy oils in winter is that they become very thick at low temperatures and hold the pistons so tightly that considerable power is required to start them.

Gravities do not play an important part in the selection of an oil. The principal points to judge by are the flash and the fire points and viscosities at 150 deg. fahr. and 350 deg. fahr. While the crankcase oil will vary also in temperature under different working conditions, in winter and summer, the point of 150 deg. fahr. has been taken as a basis of calculation, while 350 deg. fahr. more nearly approximates the condition under which the oil must work in the cylinders.

Some oils show high viscosities at 150 deg. fahr. and 212 deg. fahr., but at 350 deg. fahr. greatly reduced viscosity; others give ordinary readings at the first and

OIL SPECIFICATIONS

Oil	Gravity, deg., Baumé	Flash Point, deg., fahr.	Fire Point, deg., fahr.	Viscosity at 212 deg. fahr., sec.	Viscosity at 350 deg. fahr., sec.
*All-year	20-30	415-465	455-520	58- 85	36-40
Heavy summer.	22-29	470-530	530-600	100-125	40-45

*The cold test for these oils is preferably 20 to 25 deg. fahr. and should not exceed 32 deg.

second temperatures and drop but little at the third.

The best results will be obtained from an oil that, all other things being equal, shows the greatest viscosity at both 150 deg. fahr. and 350 deg. fahr. In other words, an oil having the proper cold test, flash and fire points and the greatest viscosity at 150 deg. fahr. and 350 deg. fahr. will give far better service as a lubricant under heavy-duty working conditions than an oil as good in all other respects but with a relatively low viscosity at 150 deg. fahr., although the latter might have the same viscosity at 350 deg. fahr., which of course is not likely to happen.

There is such a difference in oils that it is impossible to tell without actual tests or a complete, dependable table of characteristics, including viscosities at 350 deg. fahr., just which kinds will best serve a particular purpose, but the day is coming when more attention will be given to this part of the engine business and a means found of giving the needed information to engine owners.

It will be noted that in the specifications tabulated there is considerable leeway in all characteristics except the viscosity at 350 deg. fahr., universal Saybolt viscosimeter, where the limits are rather close. The oils which come within these limits naturally have the desired characteristics at the lower temperature, and flash and fire points; hence it is important that in addition to the other characteristics the viscosity at 350 deg. fahr. and a cold test be obtained.

TABLE I—FUEL TESTS WITH 1 LB. OF EACH

Engine Used—Buda HTU—High-Compression Head—Gasoline Manifold—Four Cylinders—4.25 in. by 5.50 in.—Water 120 deg. to 150 deg. fahr.—Barometer 29.5 in.

Fuels Used

	Gravity, deg. Baumé	Specific Gravity	Lb. per gal.	Gal. per lb.	Approx. B.t.u. per lb.	Approx. B.t.u. per gal.	Init. Boil'g Pt. deg. fahr.	End Point deg. fahr.	Composition, per cent: Gasoline	Kerosene	Heavy Distillate
Commercial gasoline	56.9	0.7491	6.236	0.1604	18,569	115,796	128	429	54.0	39.0	2.0
Cracked gasoline	49.3	0.7808	6.501	0.1538	18,493	120,223	120	393	46.5	49.5	3.0
Cracked benzine	44.8	0.8009	6.668	0.1500	18,494	120,224	120	423	23.0	73.5	3.5
Synthetic crude	44.0	0.8046	6.699	0.1493	18,440	123,530	120	454	31.0	65.0	3.5

Duration of run Min.	Sec.	R.P.M.	Load lb.	B.Hp.	B.Hp. per rev.	R.P.M.	B.Hp.	Internal friction Hp.	I.Hp.	Total lb. fuel per hr.	Total fuel gal. per hr.	Lb. per b.hp.hr.	Gal. per b.hp.hr.	B.hp. hr. per lb.	B.hp. hr. per gal.	Average b.hp.hr. per gal.
							Test With Gasoline									
5	55	391.0	88.0	11.46	0.2930946	400	11.62	0.80	12.42	10.14	1.6260	0.88489	0.13993	1.1300	7.04668	
4	23	591.5	87.0	17.14	0.2895270	600	17.37	1.87	19.24	13.69	2.1950	0.79860	0.12220 pls	1.2520	7.79500	
3	23	780.0	89.5	23.26	0.2982000	800	23.86	3.33	27.19	17.73	2.8430	0.76240	0.12220 pls	1.3118	8.17000	7.8
2	25	988.0	93.0	30.62	0.3099190	1,000	30.99	4.66	35.65	24.83	3.9810	0.81090	0.13000 pls	1.2330	7.68890	
2	16	1,200.0	88.5	35.39	0.2949166	1.200	35.39	6.40	41.79	26.47	4.2447	0.74795	0.12000	1.3369	8.33700	
							Test With Cracked Gasoline									
5	49	400	92.0	12.26	0.3065000	400	12.26	0.80	13.06	10.32	1.5784	0.841360	0.1295000	1.188	7.723188	
3	46	590	89.5	17.59	0.2981356	600	17.89	1.87	19.76	15.93	2.4500	0.905628	0.1392800	1.104	7.177104	
3	1	787	92.5	24.26	0.3082590	800	24.66	3.33	27.99	19.89	3.05968	0.820000	0.1261200	1.220	7.931220	7.97
2	32	993	95.0	31.43	0.3165166	1,000	31.66	4.66	36.32	23.68	3.64000	0.753400	0.1158129	1.127	8.626827	
2	11	1,200	89.0	35.59	0.2965883	1,200	35.59	6.40	41.99	27.48	4.22700	0.772000	0.1187000	1.295	8.418795	
							Test With Cracked Benzine									
5	57	395	93.0	12.24	0.309873400	400	12.39	0.80	13.19	10.08	1.512	0.8239	0.1235300	1.120	7.468160	
3	56	588	92.0	18.03	0.306632653	600	18.40	1.87	20.27	15.25	2.287	0.8460	0.1268000	1.182	7.881576	
3	16	785	94.5	24.72	0.314900000	800	25.19	3.33	28.52	18.37	2.775	0.7430	0.1122600	1.350	9.001800	8.23
2	29	983	95.5	31.28	0.318200000	1,000	31.82	4.66	36.48	24.16	3.623	0.7720	0.1158248	1.294	8.628392	
2	5	1,193	89.0	35.38	0.296563285	1.200	35.59	6.40	41.99	28.80	4.319	0.8140	0.1220700	1.230	8.201640	
							Test With Synthetic Crude									
5	17	399	91.8	12.20	0.305764400	400	12.23	0.80	13.03	11.36	1.6960	0.93085	0.13900	1.07	7.16793	
4	10	584	91.0	17.21	0.303253424	600	18.20	1.87	20.07	14.40	2.1495	0.81300	0.12190	1.23	8.23977	
3	2	780	91.5	23.78	0.304871800	800	24.39	3.33	27.72	19.78	2.9540	0.84000	0.12426	1.22	8.17278	8.02
2	28	983	92.0	30.13	0.306510680	1,000	30.65	4.66	35.31	24.32	3.6450	0.80730	0.10106	1.24	8.30676	
2	11	1,181	86.0	33.84	0.286536830	1,200	34.38	6.40	40.73	27.48	4.1020	0.81200	0.12120	1.23	8.23977	

These data are based on the requirements of an engine of the type described, in which the oil is used for lubricating all bearings as well as the cylinders, and should not be confounded with specifications that might be deemed desirable for an oil to be used in engines of other types. It was because of the excessively heavy duty this type of engine is called upon to perform that investigation of the oil problem was made. Considerable work remains to be done in this connection.

FUEL TESTS

While the engine is designed primarily for the use of gasoline, it can be provided with a low-compression head so that those desiring to use kerosene may do so by ap-

plying the additional apparatus adapted to the handling of that fuel. This is not furnished as a regular part of the equipment.

As a part of the research work carried on in connection with the HTU engine, tests were made of cracked fuels of different weights to determine whether it was possible to use such fuels in an engine of this type, designed and equipped for the use of gasoline. The results are given in Table 1. The plotted curves will more readily illustrate the results obtained. The tests were made with a regular Stromberg carbureter attached to a gasoline manifold. No hot-air stove or other means of heating was provided—in fact it was the regular gasoline equipment. A Sprague electric cradle dynamometer was used, with all the necessary equipment for weighing the fuel, counting the revolutions, timing, taking the temperature of water inlet and outlet, as well as the oil temperature in the crankcase, manifold, vacuums, etc.

This sheet shows the horsepower curves of all five tests, including the kerosene test, which was made with a low-compression head and heated manifold, but without hot air being taken through the carbureter. This particular test was made only for horsepower determination and no record was kept of fuel consumption per brake horsepower per hour.

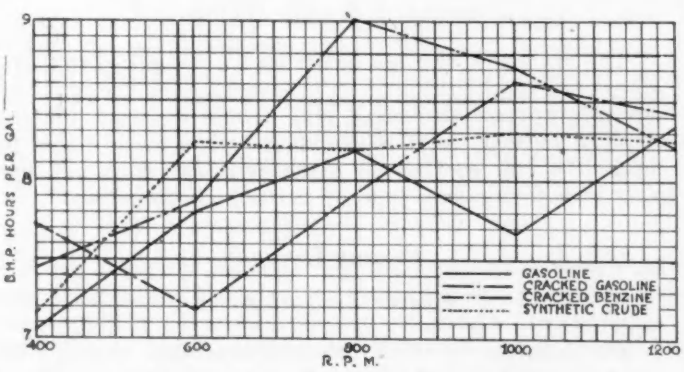
The accompanying table gives the relative rank of the various fuels at different speeds.

Fuel	Speed, r.p.m. 400	600	800	1000	1200
Cracked benzine	1	1	1	1	1
Cracked gasoline	2	3	2	2	2
Synthetic crude	3	2	3	4	4
Ordinary gasoline	4	4	4	3	3
Ordinary kerosene	5	5	5	5	5

It will be noted that ordinary gasoline gave more power than any of the cracked fuels at the last two speeds.

In all cases the cracked benzine and the cracked gasoline show power-producing quality superior to that of ordinary gasoline under exactly the same operating conditions. In each test the engine was speeded up to 1000 r.p.m. with full load, at which point the carbureter was adjusted for maximum power, after which the test was started at 400 and continued up to 1200 r.p.m. with no further adjustments.

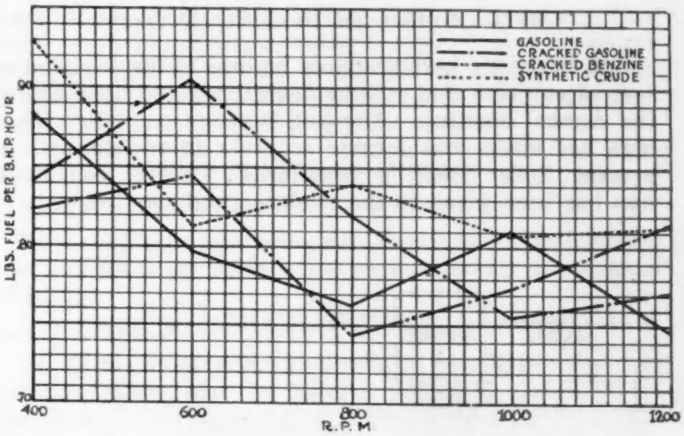
It is but fair to say that the kerosene test, which was made with a low-compression head, about 10 lb. lower than that of the other head used, does not compare favorably as to power developed. No special vaporizer or



Power Developed Per Gallon of Fuel

heating apparatus, other than the heated intake manifold, was added, and a regular Stromberg carbureter was used, as in the other tests. It was not to be expected that the showing would be what the fuel is capable of when properly handled. The power curve is given merely to show what kerosene will do in the engine with no special treatment other than the heated manifold to assist vaporization. The reasons, outside the low-compression head, for the falling off of power in the kerosene test are the loss in volumetric efficiency owing to the use of the heated manifold and the slow burning of only a part of the charge owing to lack of complete gasification.

Arrangements are now under way for making a series of tests with heavy fuels and it is hoped that within the next six months considerable progress will be made in the handling of the heavier grades of fuel, possibly even the use of distillate of 32-33 gravity.



Fuel Consumption in Pounds Per Brake Horsepower Hour

THE DISCUSSION

The discussion brought out the fact that good air cleaners will eliminate much repairing and many worn-out bearings, and that the chief reason for making the tests was to discover what was happening in the crankcase to cause so many burned-out bearings. The Buda service men were requested to send in samples of the crankcase oil in all cases of engine trouble, and in these a large proportion of dirt was found.

Mr. Dasey cited one instance of a 4½ by 6-in. engine which was used in a 5-ton truck and in which six sets of bearings had been burned out in six weeks. The owner of the truck claimed that the engine was defective, but the oil showed 100 cc. (6 oz.) of sand. In addition to the sand, 3 to 4 in. of mud was found on the bottom of the case after it had stood over night. Further investigation proved that the owner, who was a contractor, used his truck for hauling crushed stone. It was a 5-ton truck but hauled 8 tons every trip. As he ran his truck onto the stone crusher and dumped the stone in, the engine took in all the dust. The oil used was of a grade suitable for passenger cars in summer time.

In regard to the synthetic crude fuel, Mr. Dasey said it would make an ideal fuel for tractors when properly handled, and for engines of medium or low speeds. High-speed engines should be kept away from the heavy-gravity material. Further tests about to be made with the synthetic crude will probably result in some interesting discoveries. Six months undoubtedly would tell the story. He thought it would be possible to make use of the synthetic crude in passenger car engines. When asked as to ignition troubles in connection with the synthetic crude, Mr. Dasey said the only trouble had been with the points on the magnetos, due to the shortage of platinum.

Current Standardization Work

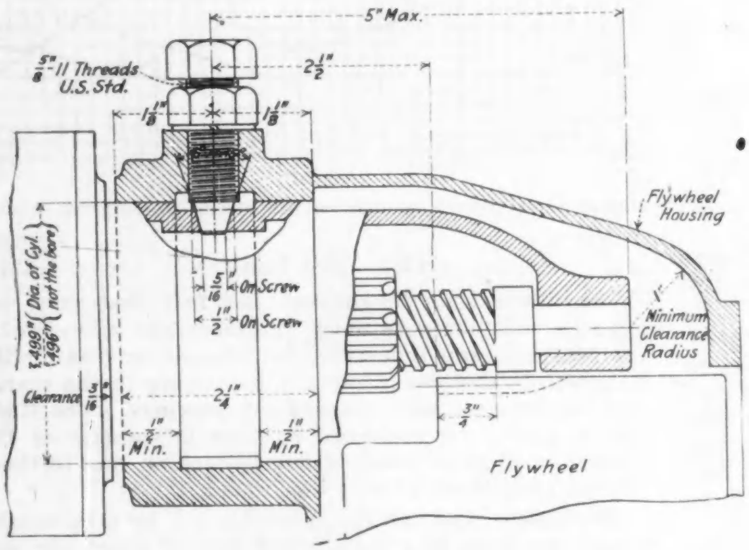
Considerable progress has been made in preparing routine engineering standards, several of the Standards Committee Divisions recently reporting recommendations that are now being prepared for publication.

Aeronautic Division

While no definite recommendations have been made by the Aeronautic Division lately, several of the important subjects are progressing satisfactorily and a definite report will probably be forthcoming at the Annual Meeting.

Ball and Roller Bearings Division

Sub-Divisions have prepared reports to the Division on several subjects that will be definitely acted upon before the Annual Meeting. The Sub-Division on Roller Bearings has made considerable progress in revision of the present Roller Bearing Standards. Careful consideration has been given to the tendency and requirements of general practice, with the result that a partially finished report by the Sub-Division favors the present series of nominal bores and outside diameters for light and medium series. Tolerances and eccentricities are to be considered further before a definite report can be made.



Section A-A

Electrical Equipment Division

Cable Terminals for Ignition Distributors, Generators, Meters and Switches

The Division has recommended the use of two types of terminals, one the usual spade type, which can be used either straight or with the wire connection set at an angle of 90 deg. to the spade, for use on terminal posts Nos. 8, 10 and 14 machine screw sizes. The other type is a flat terminal with the wire coming in at the side of the terminal and also fits Nos. 8, 10 and 14 studs. All terminals are to be 1/32 in. thick to insure proper strength. The selection of material is left to the manufacturer, it being considered that the thickness specified provides ample carrying capacity for any material. A complete report is being prepared for publication.

Sleeve-Type Generator Mounting

It is the consensus of opinion among the members who are very closely in touch with the industry that this type of generator mounting will have very little value. It is not generally used. It is therefore recommended that no standard be adopted for sleeve-type generator mounting.

Sleeve-Type Starting Motor Mounting

It is the view of the Electrical Equipment Division that this type mounting should not be used with inboard-type gear drive. A tentative recommendation has been made by the Division for outboard mesh sleeve mounting which consists of a cylindrical portion of the gear-shift housing sliding into a bored hole in the bell-housing, the length of which is about two-thirds of the diameter and the whole being locked into position by a screw through the bell housing entering a tapered hole in the cylindrical portion of the gearshift housing. This type mounting is to be used with the standard eleven-tooth pinion assembly and is to be presented for adoption as S. A. E. Recommended Practice.

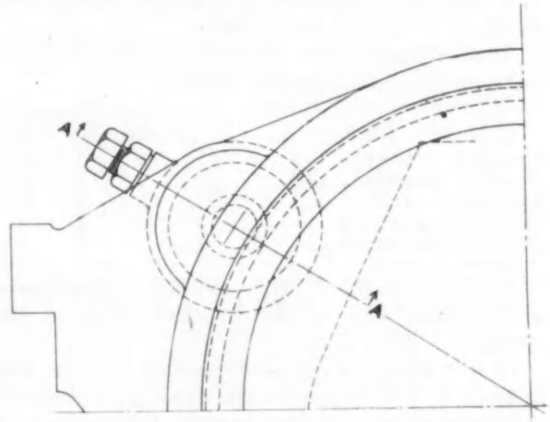


Fig. 1—Cylinder Type Mounting for Starting Motor

Rating of Storage Batteries

The rating of storage batteries for farm lighting outfits is one of the subjects in progress. It is thought that an intermittent discharge test should be used for this type of battery, as it is desirable to use thick plates for long life. A continuous discharge test does not give fair results for this type of battery construction.

Engine Division

Engine Support Arms

The Engine Division has recommended engine rear support arms in two sizes, the large one for the No. 1 S. A. E. flywheel housing and a smaller size for the Nos. 2, 3, 4 and 5 S. A. E. flywheel housings. Further standardization to include the front rocker bearing is being considered by the Division, and if it seems desirable to

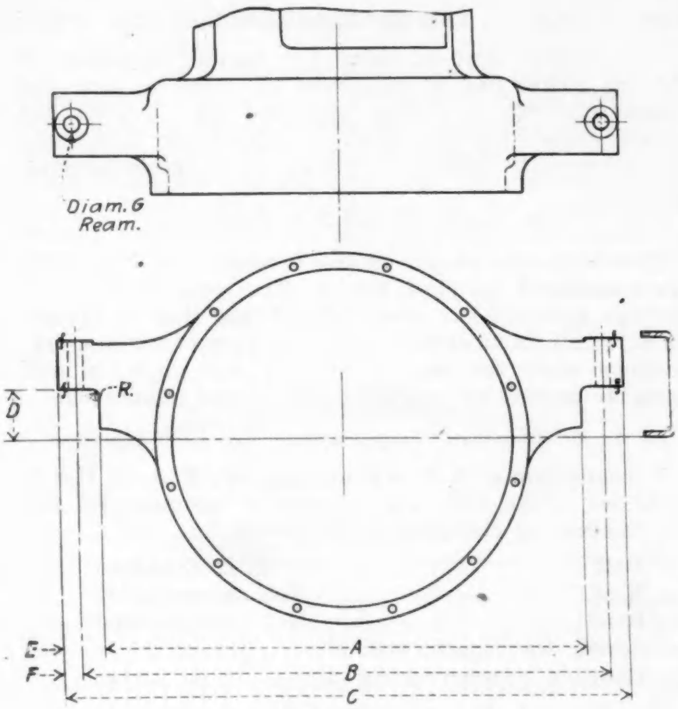


FIG. 2—ENGINE REAR SUPPORT ARMS

S.A.E. Flywheel Housing	A	B	C	D	E	F	G	R
No. 1.........	23½	26¾	28¾	2	2⅝	1	0.750	7/16
No. 2, 3 and 4.	23⅛	24½	25¾	2½	15/16	⅝	0.625	⅜

standardize this part of the mounting a recommendation will be made at a later date.

Generator Bracket Mounting

This subject includes the pad dimensions and location on the side of the engine case and is for use in conjunction with the standard generator dimensions adopted by the Society last August. In view of interferences, lack of space, particularly on the valve side of the engine, and the variety of applications of generators, the Division has recommended that no further standardization be attempted of the mounting pad cast on the engine.

Large Valves for Engines

Representative valve manufacturers with whom the Division has communicated have stated that the present standard up to and including 3-in. valve-seats covers practically all requirements. They also express the opinion that the design of valves larger than 3 in. has not yet reached a point of development that will permit of standardization, and the Division therefore recommends that no further consideration be given this subject for the time being at least.

Magneto Couplings—Flexible Disk

After carefully considering the data accumulated on this subject, the Division has made the following recommendation to cover flexible disk couplings for all magneto drives, including impulse type, and generators.

Outside diameter of disk, 2¾ in.
Inside diameter of disk, 1 in.
Diameter of bolt circle, 2 in.
Thickness of disk, ¼ in.
Number of ¼-in. bolts equally spaced, 4.

This recommendation together with the one printed on page 102 of THE JOURNAL, July, 1918, completes the S. A. E. standard for magneto couplings.

MARINE DIVISION

Swing Portlights

A Sub-Division composed of manufacturers of marine hardware and portlights has prepared a report for swing portlights in sizes of air openings 10, 12, 14, 16 and 18 in. in diameter. Sizes for smaller ports for use on yachts and pleasure craft will be worked out at an early date.

Fixed Portlights

Information has been secured covering this type of light and is now in the hands of the Sub-Division for preparation of a report to the Marine Division. This work was primarily undertaken for the marine hardware manufacturers to provide an acceptable standard largely in view of the recent war emergency as there was formerely a great variation in types and sizes.

MISCELLANEOUS DIVISION

Carbureter Hot-Air Intake Sizes

This subject is now being considered by a Sub-Division and will probably be reported on in time for the Annual Meeting.

A. S. M. E. Pitches for Machine Screws

At a recent meeting held of the machine screw nut manufacturers, and the Joint A. S. M. E. and S. A. E. Divisions it was decided that the machine screw nut manufacturers would consider organizing and that they would prepare a recommendation to the National Screw Thread Commission for a dual system of machine screw pitches.

Other screw thread subjects before the Division are progressing in coordination with work being accomplished by the National Screw Thread Commission.

Nuts for Machine Screws

In the past machine screw nuts have varied greatly in proportions. After long consideration the Miscellaneous Division, in cooperation with the A. S. M. E. Committee and the machine screw nut manufacturers, has recommended a definite series of machine screw nut sizes and proportions, which is being prepared for publication.

Spark-Plug Dimensions

A few minor revisions of aeronautic spark-plug shell dimensions are being considered by the Division, with a view to bringing the present S. A. E. Recommended Practice into harmony with a desired international standard. The Miscellaneous Division is now working on this subject. A report will probably be forthcoming in the near future.

Ball and Socket Joints

A Sub-Division of the Miscellaneous Division has under study specifications for ball and socket joints for magneto and carbureter controls. A definite report will probably be made at the next meeting of the Miscellaneous Division before the Annual Meeting of the Society.

Drag Links

This subject has been considered by the Division at some length. In view of the different grades of material, the variety of requirements met in operation and the belief that there is practically no demand for such a standard, the Division has recommended that the subject be dropped.

SPRINGS DIVISION

Spring Lengths

It is believed that in general the present standards with certain revisions will cover all practical general requirements. The Division, after reviewing the present Standards and Recommended Practices has, however, tentatively recommended a few changes in the present Standards. The tables and notes on pages 49g and 49h, S. A. E. Handbook, vol. I, Spring Widths and Eye and Clip Diameters for Passenger and Commercial Cars, are being revised and will include a series of recommended spring lengths to make them conform with present practice.

Leaf Points—Nomenclature

The leaf points shown on the present Data Sheet 49b are obsolete. The Springs Division has prepared the accompanying drawing showing a revised series of leaf points, recommending that it be adopted as S. A. E. Recommended Practice.

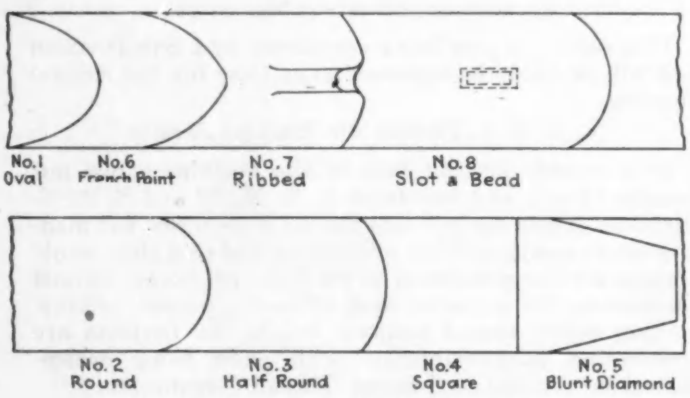


FIG. 3—LEAF SPRING NOMENCLATURE

LEAF POINTS

S. A. E. RECOMMENDED PRACTICE

Leaf Points No. 2, 3 and 4 are for recommended practice when rolled tapered leaves are used.
Leaf Points No. 4 and 5 are recommended practice when full thickness leaves are used.
All points to be chamfered for passenger cars.
Not chamfered for commercial cars.
Points may be rolled or not rolled.
Rebound clips to be used in all cases.
Leaf Points No. 1, 6, 7 and 8 are not presented as S. A. E. Recommended Practice, but for general information only.

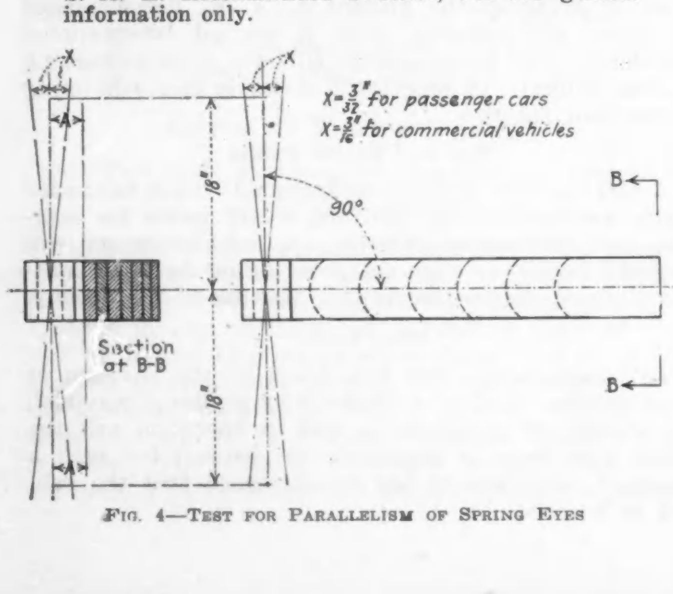


FIG. 4—TEST FOR PARALLELISM OF SPRING EYES

Test for Parallelism

The present 3/16-in. value for angular variation of the eye center line is considered too close for practical commercial vehicle spring tests and the Division has recommended that this be specified as 3/8 in. both ways for commercial vehicles as shown in the accompanying drawing.

Eye Bushings and Bolt Tolerances

The tolerances shown on the present Data Sheet 49c are considered too close for practical application. The Springs Division has recommended that they be opened up to within commercial limits. In view of certain suggestions since the recommendation was made, it will probably be revised somewhat before final publication.

S. A. E. Standard Specifications for Leaf Springs

In connection with item *F* on page 49i, S. A. E. Handbook, vol. 1, the following revision is recommended for the "method of clamping spring center."

Bolt .... (S. A. E. Standard)
Nibs .... (Not recommended)
Band .... (Not recommended)
Spring seat lengths over all..................
Distance between spring clips................

The Division has recommended that the following sketches be revised to show the position and in some instances the length of the spring seats. On page 49q, S. A. E. Handbook, Vol. I, the drawing is wrong and should be as shown in the accompanying drawing, the

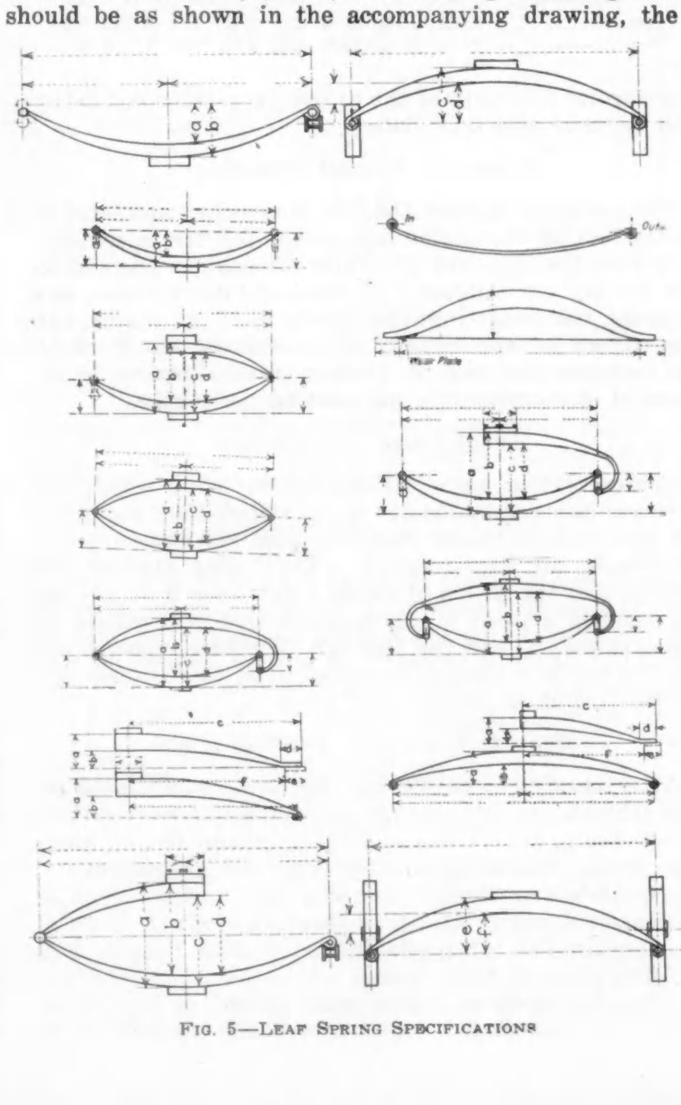


FIG. 5—LEAF SPRING SPECIFICATIONS

rollers being under the I-beam instead of under the rear end of the spring.

Tentative specifications have been prepared by the Division for the following subjects: Spring Clips for Passenger Cars, Spring Bolts for Passenger Cars, Spring Bolts for Commercial Vehicles, Spring Pins for Commercial Vehicles, and Methods of Oiling and Greasing Spring Bolts. These will be considered by the Division and definite recommendations be made probably before the annual meeting of the Society.

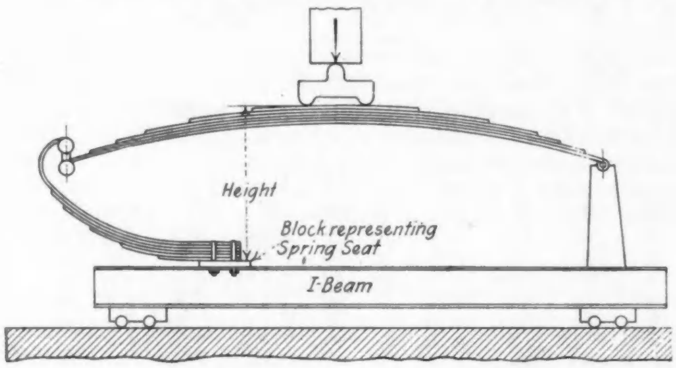


FIG. 6—THREE-QUARTER ELLIPTIC SPRING COMPRESSION-TEST SUPPORT

Finish of Springs

A tentative recommendation was made by the Division that spring finishes be classified as follows: Black—no scale removed; rough bright—scale removed by rough grinding; half bright—scale removed by rough grinding and strapping, exposed surfaces except edges polished; full bright—all exposed surfaces polished. Favorable opinions have been expressed by manufacturers for the adoption of these finishes with possibly the exception of the full bright which may be omitted when the Division makes its final recommendation.

STATIONARY AND FARM ENGINE DIVISION

As there was no quorum at the last meeting of the Division the recommendations made by those present on the following subjects must be approved by letter ballot of the Division members before finally going to the Standards Committee.

Voltage and Capacity Ratings—Farm Lighting Outfits

Where units for farm lighting plants are installed separately the belting of generators to gas engines seems to be necessitated by the current practice of building dynamos to operate at about 1800 r.p.m. while gas engines usually run at normal speeds up to about 1000 r.p.m. It would mean a great deal not only to farmers but to farm lighting equipment manufacturers if the former were able to buy generators and gas engines to run at the same speed as direct-coupled units. It is believed by the Division members that a standard series of ratings, voltage and speeds is practicable and desirable. The following proposal has been presented for consideration before final recommendation by the Division.

FARM ELECTRIC LIGHTING PLANT

Normal rating, kw.	Volts	Engine and generator speed, r.p.m.
½	32	1,000
¾	32	1,000
1	32	1,000
1½	32	1,000
2	32	1,200
3	32	1,200
5	32	1,200

In proposing the 32-volt system for standard, consideration was given the fact that 110-volt equipment is used extensively and replacements easily made from even the small dealer's stock. However, 32 volts has been standardized for railroad lighting equipment and many other purposes and supplies are becoming more and more available every day, so that in view of the desirability from other standpoints of using this voltage the Division considers it well to recommend it for standard practice.

Flanges for Cast-Iron Carbureters

Cast-iron carbureters are manufactured and used extensively but the present S. A. E. flange standards are not suitable for this material which has to be made considerably heavier in section than brass, particularly in the walls of the castings. With the present standard hole center distances, considerable trouble is had with the breaking of drills and taps because of their running into the metal of the sidewalls.

The Division has, therefore, prepared a series of cast-iron carbureter flanges to be approved by the industries generally before it is finally recommended for S. A. E. adoption.

Pipe Flanges (Oval and Round)

Round flanges conforming to the A. S. M. E. and the American Manufacturers' Standards are carried in stock by fittings manufacturers generally, and are recommended as suitable for use on stationary farm gas engine exhaust pipes.

As an alternative for use where the space is too limited to use the four-bolt round type, an oval type is proposed for S. A. E. standard.

Adaptability of S. A. E. Engine Testing Forms

The adaptability of the S. A. E. Engine Testing Forms for stationary engine and farm lighting outfits was carefully studied by a Sub-Division which suggests the following additions to the present sheets: Sheet A is satisfactory in its present form. Sheet B is satisfactory with the addition of a space for "normal r.p.m." and a space for "normal horsepower." Under Lubrication System, provision should be made for indicating the cooling system as "air cooled" or "water cooled," and under "water cooled" provision made for "radiator-capacity in gallons and pounds," for "tank-capacity in gallons and pounds" and for "hopper-capacity in gallons and pounds." It is also recommended that the item Piston Rod Bearings be changed to Piston Pin Bearings as being a little clearer in meaning. In sheet C in the first section it is suggested to add Weight of Water Evaporated after the item Temperature of Water-Out, the same item to be added after Mean Temperature Jacket Water in the second section on this sheet. On curve sheet D it is proposed to add a new series of r.p.m. ranging from 100 to 1300 as the range of present r.p.m. would make the curves plotted to it so short that they would be valueless due to the low speed ranges of stationary gas engines.

TIRE AND RIM DIVISION

As the meeting at which the following recommendations were made lacked one of a quorum, they are subject to confirmation and approval by the whole Division before they can be formally reported to the Standards Committee.

Solid Tire Sizes

The present S. A. E. standard is for nominal tire diameters of 34, 36 and 40 in. only. The subject of Solid Tires was taken up in a manner similar to that in which the pneumatic tires, already standardized, were handled. The Tire and Rim Division has given the proposed series of solid tire sizes careful consideration and although they realize that the schedule cannot be conformed to without working more or less hardship on a few truck manufacturers, it is considered desirable to establish a definite S. A. E. standard list of sizes toward which all the manufacturers can work, making their change-overs within such time as is feasible without causing hardship. A definite standard will also be of material value to the wheel builders as represented by the Automotive Wood Wheel Manufacturers' Association. It is, therefore, recommended by the Tire and Rim Division that the S. A. E. revise the solid tire standard as now printed on Data Sheet 8, vol. I of the S. A. E. Handbook, and adopt for S. A. E. standard the sizes given below; thus conforming with the permanent (Class A) standard solid tire sizes recommended and adopted by the War Service Committee of the Rubber Industry of the U. S. A. To make the standard complete the same as the present pneumatic tire series and to provide definite data for manufacturers branding metric dimensions on their tires, it is also recommended that a parallel column of metric equivalent sizes be shown in the standard. The complete table as recommended is:

SOLID TIRE SIZES

Inches	Mm.	Inches	Mm.
32x3½	90/660	36x7	175/762
36x3½	90/762	40x7	175/864
32x4	100/660	36x8	200/762
36x4	100/762	36x10	250/762
36x5	125/762	40x10	250/864
40x5	125/864	40x12	300/864
36x6	150/762	40x14	350/864
40x6	150/864		

A tentative recommendation for consideration by the Division members is made with the idea of establishing front and rear truck wheel sizes which the Automotive Wood Whel Manufacturers' Association has already adopted, as follows:

TIRES FOR SINGLE WHEELS

32x3½	36x5
36x3½	36x6
32x4	36x7
36x4	36x8 (fits 36x4 dual wheel)

TIRES FOR DUAL WHEELS

36x4
36x5
40x5
40x6
40x7
36x10 (Single tire fits 36x5 dual wheel)
40x10 (Single tire fits 40x5 dual wheel)
40x12 (Single tire fits 40x6 dual wheel)
40x14 (Single tire fits 40x7 dual wheel)

Such a standard is considered desirable as it will greatly assist wheel manufacturers in the elimination of an unnecessary variety of sizes.

Base Bands for Solid Tires

The proposed base-band dimensions for S. A. E. standard is shown below. This conforms to the proposed series of solid tire sizes and is in accordance with the base bands recommended and adopted by the War Service Committee of the Rubber Industry of the U. S. A. The proposed standard relates to corrugated mill sections and it is optional with tire manufacturers to use either mill corrugated or dovetail facings as the same general dimensions apply to both kinds of section.

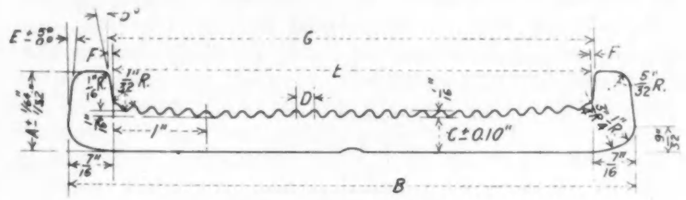


FIG. 7—BASE BANDS FOR SOLID TIRES

Size	A	B	Limits of B	C	CORRUGATIONS No.	Width D	E	G	F
3	23/32	3 3/4	±1/32	1/4	16	0.181	2 29/32	3 1/16	5/64
3½	3/4	4 1/4	±1/32	9/32	18	0.191	3 7/16	3 9/16	1/16
4	25/32	4 13/16	±1/32	5/16	20	0.196	3 59/64	4 1/16	9/128
5	27/32	5 7/8	±1/32	3/8	26	0.189	4 59/64	5 1/16	9/128
6	27/32	6 7/8	±1/32	3/8	32	0.185	5 59/64	6 1/16	9/128
7	27/32	7 7/8	±1/32	3/8	36	0.192	6 59/64	7 1/16	9/128
8	7/8	8 7/8	±3/64	3/8	40	0.196	7 27/32	8	5/64
10	7/8	10 7/8	±3/64	3/8	50	0.196	9 27/32	10	5/64
12	7/8	12 7/8	±3/64	3/8	60	0.197	11 27/32	12	5/64
14	7/8	14 7/8	±3/64	3/8	70	0.197	13 27/32	14	5/64

Industrial Truck Tires

It was found upon investigation that there is little uniformity in present practice for industrial truck tire sizes. After carefully considering the situation the Tire and Rim Division recommends that the following industrial truck tire and wheel dimensions be adopted for S. A. E. standards:

TIRE DIMENSIONS Nominal diameter in.	Sectional widths in.	WHEEL DIMENSIONS Wheel diameter in.	Widths of Felloes in.
10	3½	6	2¾
10	5	6	4¼
16	3½	12	2¾
16	5	12	4¼
20	3½	16	2¾
20	5	16	4¼
24	3½	20	2¾
28	3½	24	2¾

Wheel diameters shall be 4 in. less than the nominal tire diameters. The height of the finished tire is to be 2 in. for all sizes. The width of the wheel felloe is to be in accordance with the present S. A. E. standard truck tire practice and the rim diameter tolerances will be plus zero, minus 0.005 in. The acceptance of this recommendation would make all the former or present S. A. E. standards for industrial-truck tire sizes null and void.

Base Bands for Industrial Truck Wheels

The sections of tires and base bands as recommended for solid tires for trucks also apply to industrial-truck wheels, and the Division recommends that the proposed S. A. E. standard 3½ and 5 in. pressed-on channel sections be adopted for industrial-truck wheels according to the accompanying drawing.

Allowable Tolerances for Felloe Bands

The tolerances given on Data Sheet 8a, vol. 1, S. A. E. Handbook, are used for the inspection of not only steel

bands on wood wheels but also steel wheels. The Division recommends that the wording at the bottom of page 8a, be changed to read, "Band circumference after application to wood wheels and circumferences of steel wheels." Careful consideration was given also to changing the tolerances on band circumferences before application. On account of the difficulty of inspecting the circumferences with a tape to the present close tolerances the Division recommends that the tolerances for "Band circumferences before application" be changed to plus 1/32 minus 1/16 in. to allow commercial tolerances.

Edges of Felloe Bands

The present specification as revised at the June meeting in Dayton to 3/16 in. radius on the inside edges and 1/16 in., radius on the outside edges of band, is a specification to which it is practically impossible to get the mills to roll steel. The Division therefore recommends that the edges of the felloe band be changed to 3/32-in. radius for all edges. This proposal is approved by both wheel and tire manufacturers.

Wood Felloe Dimensions—Pneumatic Tire Rims

At the June, 1918, meeting of the Society wood felloe dimensions were adopted for only the 6, 7 and 8 in. rims. To complete this specification for 3½, 4 and 4½ in. rims, the dimensions recommended for S. A. E. standard are as follows, for all pneumatic tire rims:

Nominal Tire and Rim Size	Width	Depth
30x3½	1½	1¼ + 1/16 — 0
32x3½	1½	1¼ + 1/16 — 0
33x4	1¾	1¼ + 1/16 — 0
34x4½	*2 †2⅛	1¼ + 1/16 — 0

*Width of felloes for rims with special sections.
†Width of felloes for demountable rims on cold-rolled bands.

These felloe band dimensions conform with those adopted by the Automotive Wood Wheel Manufacturers' Association.

Pneumatic Tires for Motorcycles

The present S. A. E. motorcycle tire sizes are somewhat out-of-date. The Division therefore recommends that the following be adopted for S. A. E. standard motorcycle tire sizes:

Nominal Tire Size in.	Nominal Tire Size mm.	Oversize Tire in.	Oversize Tire mm.	Tire Seat, Diameter of rim in.	Tire Seat, Diameter of rim mm.	Type of Rim
26x2¼	60/535	None	None	21	535	BB
28x3	75/560	29x3½	90/560	22	560	CC

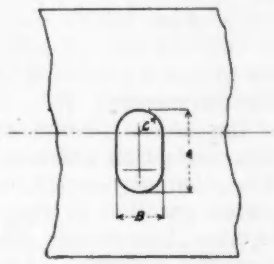
These sizes conform with those adopted by the War Service Committee of the Rubber Industry of U. S. A.

Wood Spokes—Passenger Car Wheels

Wood spoke dimensions have already been standardized for commercial vehicles. The Division now recommends a series of dimensions for wood spokes for passenger car wheels. The drawings which conform with those of the Automotive Wood Wheel Manufacturers' Association are now being prepared for publication.

Valve Hole Size—Automobile Rim

A ⅝-in. diameter valve-hole has already been standardized for the 3½, 4 and 4½ in. rims. The Division



*Rim Size (Inches)	Valve Hole (Inches) A	B	C
6	1⅛	⅝	5/16
7	1½	⅝	5/16

FIG. 8—VALVE HOLE SIZE FOR GIANT DEMOUNTABLE AND STRAIGHT SIDE TRUCK RIMS

now recommends valve-hole sizes for the 6 and 7 in. rims as shown on the accompanying drawing, to be included with the present standards.

Solid Tire Sections and Contours

In first working on this subject the idea was to standardize the section contours for solid tires but as this would tend to limit the design of solid tires, the Division recommends that the minimum total cross-sectional rubber area of solid tires on standard bands for commercial wheels shall be as shown in the accompanying table, which is in complete accord with the schedule worked out and adopted by the Solid Tire Division, War Service Committee of the Rubber Industry of the U. S. A. These areas include the hard and soft rubber used in solid tires.

Solid Tire Widths, In.	Minimum Total Sectional Area of Rubber, Sq. In.
3½	6.75
4	7.75
5	10.75
6	13.75
7	16.75
8	19.75
10	25.75
12	31.75
14	37.75

Solid Tires for Tractors

The Division is taking up this subject at the present time as manufacturers are being called upon for tractors to do road hauling. This use of solid tires on tractors is new and it seems opportune to provide a satisfactory standard for tractor and tire manufacturers' use instead of waiting until a variety of designs, some more or less impractical, become established. To bring the ideas and designs of the tractor makers into accord with practical tire manufacturing methods, the tractor manufacturers are requested to submit data to the Standards Department of the Society. These data should include designs which engineers have in mind or which have already been tried out and proved of worth. As soon as an analysis of the data submitted can be made it is intended to bring the tractor and tire manufacturers together in a joint meeting to plan tentative recommendations.

ALCOHOL, INTERNAL-COMBUSTION ENGINE FUEL

A COMMITTEE has been appointed by the British Government to investigate the available sources of supply of alcohol with particular reference to its manufacture from materials other than those which can be used for food purposes, and also the method and cost of such manufacture and the manner in which alcohol should be used for power purposes. In commenting upon the appointment of this committee the *Motor Trader and Review* says, "The question of the production and use of alcohol for power purposes, and particularly as the fuel for motor cars in place of imported gasoline, is one on which probably more has been written than on any other subject associated with the automotive industry. Long before the war it was felt that the motor traction movement must eventually develop so as to render it impossible to continue to rely for power on a liquid fuel obtained entirely from other countries. During the war period the weakness of Great Britain along this line was demonstrated not only by advances in price but in restrictions on the use of private and commercial motor vehicles. Whether or not the new departure denotes that the Government has at length realized the seriousness of the position, it is certainly a step forward to have a committee of experts appointed to consider the whole subject of alcohol as an engine fuel."

There is ample evidence, the article states, that alcohol can be produced in large quantities and there is no reason why a large proportion of the State and civil requirements of alcohol for internal-combustion engine fuel cannot be met from agricultural products raised in Great Britain, while sufficient land is available in the colonies and dependencies for the growing of alcohol-producing crops sufficient to meet the engine fuel requirements of the entire British Empire.

Alcohol Manufacture in South Africa

The South African Industries and Advisory Board has recently issued a report on the manufacture of industrial alcohol in which it recommends that steps be taken to remove the obstacles preventing the manufacture and use of industrial alcohol within the Union of British Colonies in South Africa. In 1915, all the alcohol engine fuel consumed in South Africa, amounting to 5,217,914 gal., was imported. The feasibility of producing sufficient alcoholic engine fuel from local spirits has already been proved, according to the report, and one plant will be put in operation early in 1919. The Board recommends that the alcohol fuel when manufactured and ready for use as such in internal-combustion engines shall contain in 100 volumes not less than 2 volumes of approved wood naphtha and not less than one-half a volume of approved pyridine bases, with a further provision that if the fuel contains ethyl ether each 100 volumes shall contain 1 volume of approved wood naphtha or 1 volume of approved benzine for every 10 volumes of ether. While the materials required to denature the alcohol have to be imported and are relatively expensive at the present time, it is expected that before long they can be manufactured in South Africa.

Alcohol-Gasoline Mixtures

From limited experiments that have been made, F. B. Swingle, Associate Editor of the *Wisconsin Agriculturist*, is of the opinion that the alcohol purchasable on the market does not mix satisfactorily with gasoline in a fifty-fifty proportion. He states, however, that a perfect mixture has been formed by adding 1 per cent of benzol to a half-and-half mixture of alcohol and gasoline.

The great problem today is the manner in which the farmer, as producer of the raw products, is to be induced to produce alcohol under Government supervision, as permitted by the 1907-1914 laws. The greatest difficulty seems to be in his securing a small still for the purpose. It is thought that the manufacturers of small stills are not quoting prices this year.

Mr. Swingle states that a small, continuous, automatic still which has been manufactured will distill water or alcohol at a cost of 1½ cents per gal.

STANDARDIZATION OF FREIGHT CARS AND LOCOMOTIVES

IT is said that 2023 different styles of freight cars and almost as many different descriptions of locomotives were included in the equipment of American railroads prior to the war. The facts are not known, but nearly every important railroad had its own specifications for cars and engines. None of these was identical, and they were generally changed in some detail when new orders were placed. There were box cars of both steel and wood, gondola cars, flat cars, hopper cars, refrigerator cars, tank cars, automobile cars, furniture cars, cattle cars, and many other sorts of cars suited to the different varieties of traffic. The lack of standardization increased the difficulties of repair when these cars were off the lines of the roads which owned them. Parts were not interchangeable and it was often necessary to telegraph the owning road for them before repair work of even the simplest nature could be performed.

In a general way the same thing was true of the locomotives in use. Complete standardization will of course be impossible until the rolling stock and engines now in use shall have been entirely replaced by standardized types. Progress has, however, been made. Some twelve standard types for freight cars have thus far been agreed upon, and it has also been decided that hereafter only six types of locomotives of two weights each shall be purchased. The parts of these various types of locomotives and freight cars will be interchangeable. Their construction will be uniform, and when repairs are needed they can be made with the greatest possible promptitude. The equipment of all the railways Dec. 31, 1917, included about 2,400,000 freight cars and 64,750 engines.—Director General of Railroads McAdoo.

FREIGHT CAR AND MOTOR TRUCK

THE motor truck and the freight car each has its place, and when used in that place will be found to be more efficient than the other. You cannot guess at it however. You must admit and show on your records what constitutes legitimate costs in the two classes of service, and determine by comparison the superiority of one over the other in the business or on the line in question.

George W. Veale.

Activities of S. A. E. Sections

THE December meeting of the newly formed Washington Section was held in the auditorium of the New Interior Building on the 11th. After an exhibition of two reels of motion pictures showing in detail the correct method of handling the Lewis machine gun, A. G. Gloetzner, who spent some time abroad as a member of a special mission investigating the question of motor truck transportation, delivered an address dealing with the use of the trucks in France and the conditions under which they operated. The presentation was supplemented by a number of lantern slides showing some of the vehicles in use, the facilities provided for the repair of damage done by shell fire and other things, and views of conditions of the roads and structures over which the vehicles had passed.

At the Minneapolis Section meeting, held on Dec. 4, a paper on "Tractor Drawbar Implements and Their Hitches" was presented by F. N. G. Kranick of the Hyatt Roller Bearing Co. In the paper data were presented which Mr. Kranick had acquired through field research work in conjunction with manufacturers of tractors and implements. C. M. Bawlf, formerly of the Royal Air Force, delivered an address on "Bombing and Bombing Planes."

The December activities of the Metropolitan Section included an excursion to the Long Island City plant of the Wright-Martin Aircraft Corporation on the 7th. At this plant the 300-hp. high-compression Hispano-Suiza engines are being produced. This excursion was a supplement to the one to the New Brunswick plant on Nov. 2.

The monthly meeting of the Section was held on the 11th. Harold L. Pope, who had recently returned from a trip to France and England to study aircraft designs, addressed the meeting, as did also Mr. Griffin, of the British Mechanical Transport Corps. The paper of the evening was presented by F. Leigh Martineau of Great Britain, his subject being "Hydraulic Transmission." This paper will be printed, together with the discussion, in an early issue of the JOURNAL.

On Dec. 16, through the courtesy of H. B. Mingle, president of the Standard Aircraft Corporation, the Section held an excursion to the plant at Elizabeth, N. J. The members upon arriving at Elizabeth were taken through the various departments, and luncheon was served in the company's dining room. In the afternoon further inspection of the process of manufacturing was made.

The December meeting of the Cleveland Section was held at the Hotel Statler on the 20th. A paper on "Cooling" was presented by J. H. Harris, engineer of the McCord Radiator Co., Detroit, Mich.

The first meeting of the season of the Pennsylvania Section was held at the Hotel Adelphia, Philadelphia, Dec. 6. It was preceded by a dinner at which about 50 members and guests were present, and after the dinner plans were discussed for the work of the coming season. A number of the members gave their views. It was the almost unanimous opinion of the speakers that the papers to be presented should deal with subjects of national importance or of interest to the members of the Section rather than any highly technical papers. In this connection it was planned to send a questionnaire to the members to secure an expression of opinion as to what form the meetings should take, whether they should be preceded by a dinner, and the papers presented should deal with strictly technical subjects. A plan for holding the meetings in cities other than Philadelphia was discussed, and it was voted to hold the next meeting of the Section at Wilkes-Barre. An excursion to the plant of the Sheldon Axle Co. will probably be part of the program.

The December meeting of the Mid-West Section was held on Dec. 6. A paper on "The High-Compression Oil Engine" was presented by W. G. Gernandt, vice-president and general manager of the Gernandt Motor Corp., Chicago, who discussed the various principles of fuel injection and the possibilities of using low-grade fuels, and drew comparisons between the Otto and Diesel cycle engines. Another paper on "Scrap Organization and Scrap Salvaging" was read by Lieut. Charles A. Reagan, U. S. A., Chicago district manager stores and scrap section.

The January meeting of the Minneapolis Section will be held on the 8th. The general subject for discussion will be Engine Governors and papers will be presented by F. H. Critchfield, Pierce Governor Co., and E. B. Stone, Remy Electric Co. Representatives of other governor manufacturers will also be present and participate in the meeting.

CHARLES S. BEACH, an Associate Member of the Society, died at his home in New York City on Oct. 26. Mr. Beach was born and educated in Baltimore. His aptitude for things mechanical was apparent at an early age and he was soon engaged in such practical work as is open to boys while still in school. He took a keen interest in airplane and automobile work, and his unusual grasp of mechanical problems is shown by his rapid advance. Mr. Beach began business life as a demonstrator of automobiles, and spent a year or two in travel in connection with this work. He then took a position as shop superintendent and continued in this responsible and exacting work until his death. For the past four years he was with the Willys-Overland Company, New York City.

JOHN E. GENN died at his home in New York City on Dec. 15. He was born in 1883 at Connersville, Ind. Mr. Genn was with the Pope Mfg. Co. for seven years and became an Associate member of the Society in 1913, at about the time of the organization of the Stewart-Warner Speedometer Corp. He was one of the first ten members of that organization, passing rapidly through the positions of engineer, assistant chief engineer and chief inspector, to that of chief engineer, which he held at the time of his death. He was transferred to the Member grade in 1917. A widow and two sons survive him.

Mr. Genn was a member of the Miscellaneous Division of the Standards Committee of the Society.

PERSONAL NOTES OF THE MEMBERS

E. P. Gould has resigned his position with the Sumpter Division of the Splitdorf Electrical Co., Chicago.

E. A. Field has resigned as president and general manager of the Field Motor Co., Grand Rapids, Mich. He has not made any plans for the future.

R. K. Jack, who has been manager of Arrol Johnston, Ltd., Dumfries, Scotland, builder of vertical, V and radial airplane engines for the past two years, will return to this country shortly.

V. L. Kloepper has left his position as designing engineer for the Dorris Motor Car Co., St. Louis, to become chief engineer in the Automotive Department of the National Tool Co. of that city.

Samuel C. Kyle is leaving the firm of A. C. Clark & Co., Chicago, to connect with the U. S. Ball Bearing Co., as Pacific Coast manager. He will have offices in the Rialto Building, San Francisco.

Capt. Victor W. Pagé, who has been serving in France for some months past, has been promoted to the rank of major. He has been chief aeronautical engineer of the Third Aviation Instruction Center of the A. E. F., which has been the world's largest aviation school for some time past. Major Pagé joined the Air Service in February, 1917, resigning his position at that time as experimental engineer for the New Departure Mfg. Co., Bristol, Conn. He was one of the first of the Society members to join the army as well as one of the first to be assigned to active duty. He was first engineer officer and officer in charge of technical instruction in the Signal Corps Aviation School at Hazelhurst Field, Mineola, N. Y., and was subsequently transferred to staff duty in Washington. He was sent to Europe as head of a special technical mission to investigate aeronautical engineering progress and was assigned to permanent active duty after he had completed his special mission.

C. E. Stoltz, who has until recently been engineer and superintendent of the Robinson Fire Apparatus Mfg. Co., St. Louis, is now chief engineer of the Mancha Storage Battery Locomotive Co., in the same city.

T. J. Turk, formerly connected with the Kissel Motor Car Co., and General Motor Truck Co., has resigned his position as assistant general manager of the Inter-State Motor Co. He was responsible for the design and production of the inter-state touring car, and of late has given his entire attention to the reorganization of this company, preparatory to building artillery tractors. His plans for the future are not yet made.

Andrew L. Vargha until recently in business in Detroit has removed to Shreveport, La., to take up work as designer for the Louisiana Motor Car Co.

H. C. White has been appointed factory manager of the Harris Mfg. Co., Stockton, Cal., and will enter upon his new duties, Jan. 1.

Applicants *for* Membership

The applications for membership received between Nov. 15 and Dec. 15, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ATWELL, NORBERT S., mechanical engineer, A.P.S.L., Bureau of Aircraft Production, Gages and Standards, *Dayton, Ohio*.

BARTON, FRED. C., application engineer, Bijur Motor Appliance Co., *Hoboken, N. J.*

BASQUIN, O. H., expert consulting work, Haskelite Mfg. Corp., Chamber of Commerce, *Chicago, Ill.*

BECKER, DEWEY H., sergeant, draftsman, 811th Aero. Squadron, The Speedway, *Indianapolis, Ind.*

BEIGER, JOHN W., chief engineer and manager of factories, Haskelite Mfg. Corp., *Grand Rapids, Mich.*

BERTRAND, A. A., general superintendent, Chalkis Mfg. Co., *Detroit, Mich.*

BLODGETT, WALTER P., manager of engineering, Standard Aircraft Corp., *Elizabeth, N. J.*

BOTZENHARDT, EUGENE W., body draftsman, Dodge Brothers, *Detroit, Mich.*

BROWNBACK, HENRY LOWE, mechanical engineer, officer U. S. Army, Aircraft Production, A.E.F., *France*.

BUTTERFIELD, ROY O., chief of inspection, Velie Motors Corp., *Moline, Ill.*

CAMERON, EDWARD W., inspector, Mechanical Transport Dept. M. & D., Quartermaster General's Branch, *Ottawa, Canada*.

CARPENTER, FREDERICK S., captain, A.S.A.P.U. Bureau of Aircraft Production, *Washington*.

CARPENTER, RALPH E., manager of laboratories and director of service, The Aluminum Castings Co., *Cleveland, Ohio*.

CARROLL, GUY B., instructor in naval aeronautics, Dunwoody Institute, *Minneapolis, Minn.*

CASTOR, STEPHEN R., chief draftsman, New Process Gear Corp., *Syracuse, N. Y.*

CHANDLER, A. D., sales engineer, Wilcox Bennett Carbureter Co., *Minneapolis, Minn.*

CHILD, THOMAS E., instructor, Naval Aviation Detachment, Mass. Inst. of Tech., *Cambridge, Mass.*

COLE, F. J., chief consulting engineer, American Locomotive Co., *Schenectady, N. Y.*

COONEY, ALBERT E., chief tool designer, Curtiss Aeroplane & Motor Corp., *Hammondsport, N. Y.*

CORCORAN, EDWARD S., engineer in charge military truck production, Kelly Springfield Motor Truck Co., *Springfield, Ohio*.

CRIQUI, C. A., president, general manager, Sterling Engine Co., *Buffalo, N. Y.*

DAVISON, G. C., vice-president, Electric Boat Co. and New London Ship & Engine Co., *Groton, Conn.*

DAVIDSON, J. BROWNLEE, professor, University of California, *Berkeley, Cal.*

DEAN, ERNEST W., petroleum chemist, U. S. Bureau of Mines, *Pittsburgh, Pa.*

DICKERSON, CLOYD, inspecting foreman of fusilage tests, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

DRAKE, CHARLES BRYANT, brigadier-general (mail) Adjutant General's Office, *Washington*.

DUDLEY, A. MANSFIELD, engineer in charge automotive equipment, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

DURKEE, CHARLES D., president, Charles D. Durkee & Co., *New York City*.

ELLIOTT, A. M., factory manager, McGraw Tire & Rubber Co., *E. Palestine, Ohio*.

ENGLAND, W. ERNEST, chief draftsman, Root & VanDervoort Engineering Co., *E. Moline, Ill.*

ERSKINE, JOHN STEVENSON, designer of radiators and special tools for their manufacture, McCord Manufacturing Co., *Detroit, Mich.*

FALES, DEAN A., mechanical engineer, instructor, Mass. Inst. of Tech., *Cambridge, Mass.*

FALES, HERBERT G., ensign, U. S. N. R. F., office of inspector of airplane engineering material, *Buffalo, N. Y.*

FINN, J. EDGAR, manager, proprietor, garage, 688 E. 4th St., Flatbush, *Brooklyn, N. Y.*

FISHER, A. W., sales engineer, Hyatt Roller Bearing Co., *Chicago, Ill.*

FOSTER, SHUBEL A., chief tool designer, Trego Motors Corp., *New Haven, Conn.*

GIBBS, WILLIAM K., publicity, Gibbs Service, 1603 Tower Bldg., *Chicago, Ill.*

GOTTLIEB, OSCAR F., superintendent of inspection of metal and vendor parts, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GUTHRIE, ROBERT G., efficiency engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

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Applicants *Qualified*

The following applicants have qualified for admission to the Society between Nov. 15 and Dec. 17, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

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Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

ENGINEERING DRAWING. A manual for students and draftsmen. By Thomas E. French, M.E. Published by McGraw-Hill Book Co., New York City. Cloth, 6 by 9 in., 329 pp. Price $2 net.

This is the second edition published this year of the work by Professor French, who holds the chair of engineering drawing in Ohio State University. The first edition, issued in 1911, has been through ten printings. The use of this book in many technical schools has resulted naturally in constructive criticism. In the present edition a chapter on lettering in adequate form appears, and a more extended treatment of working drawings is given.

The book is adapted to advanced courses in machine drawing. The group arrangement provides series of problems for either long or short courses.

Current engineering and drafting-room practice is illustrated in the figures and problems, most of these having been adapted from the industries. There is extended discussion of the practical modification of theory when applied to commercial work, with suggested treatments of many cases which are often perplexing to draftsmen.

Professor French believes that drawing is a real language, to be studied and taught in the same way as any other language.

The book contains eighteen chapters, together with an appendix of tables of engineering practice, and an index. There are separate chapters on pictorial drawing and technical sketching; also on architectural drawing, and map and topographical drawing.